

AMMUNITION.

75
G. No.
727

A DESCRIPTIVE TREATISE

ON THE DIFFERENT

PROJECTILES, CHARGES, FUZES, ROCKETS, &c.,

AT PRESENT IN USE FOR

LAND AND SEA SERVICE,

AND ON

OTHER WAR STORES MANUFACTURED IN THE
ROYAL LABORATORY.

Part II.—Ammunition for Rifled Ordnance.

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PREFACE.

THE object of the following notes on ammunition for rifled ordnance in the Royal Laboratory, is to supply information on this subject in a form ready for reference, hence it is essential that every store should be dealt with on one system, and that the plan of the book should be clearly explained, for this the reader is referred to the key. A full index is also necessary, and this is best effected on the principle adopted for the "Changes in War Stores," that is to say, a fresh index will be issued with each number embracing the subjects in all previous ones.

In printing these notes in continuation of Captain Majendie's work on smooth-bore *matériel*, I would apologise for the matter being at times ill digested. It is very desirable to supply information, and I feel it a duty as captain instructor of the department, to do this as far as time and opportunity permit, and this without further delay, for I have learned that to wait till questions are worked out on sure grounds and settled, is to wait indefinitely.

I have taken pains to give facts and figures correctly, with references in support of my statements.

Opinions may be occasionally expressed in notes, and they may even creep almost unperceived into the text; officers placed as it were near the focus of development of war *matériel*, can hardly fail to form opinions such as ought to be useful, although in the case of stores recently introduced, their conclusions may be shown in time to require modification, and at all events do not stand on the ground of the authority claimed for the facts and figures; in short, the reader must take them for what they appear to be worth.

I would conclude by saying that I owe a great part of my information to many officials in the Royal Laboratory, as well as to the Experimental and Chemical Departments. Few persons would readily realise the labour required to obtain, and carefully compare information from the various sources within reach; those who have assisted me in the above departments, however, will I think, not only realise it, but also will be glad when such work is finished. It is especially due to the sergeant instructors of the department to notice their readiness to work for hours at night in copying out rough notes, and this after having been employed all day in the tedious work of instruction, or in collecting and comparing information.

C. O. B.

Royal Arsenal, September 1870.

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KEY.

The general plan of the work is the same as that adopted by Captain Majendie in his notes on the smooth-bore *matériel*, and in point of fact the plan on which he had commenced this part of the course, when owing to pressure of work, the duty of taking it up naturally fell to me.

1. PROJECTILES.
2. CHARGE.
3. MEANS OF FIRING CHARGE.

The following abbreviations will be found not only in this work but in many official papers, viz. :—

L.S.	-	-	For	-	-	Land Service.
S.S.	-	-	"	-	-	Sea Service.
G.S.	-	-	"	-	-	General Service.
O.P.	-	-	"	-	-	Old Pattern.
N.P.	-	-	"	-	-	New Pattern.
R.L.	-	-	"	-	-	Royal Laboratory.
M.L.	-	-	"	-	-	Muzzle-loading.
B.L.	-	-	"	-	-	Breech-loading.
M.L.O.	-	-	"	-	-	Muzzle-loading Ordnance.
M.L.R.O.	-	-	"	-	-	Muzzle-loading Rifled Ordnance.
B.L.R.O.	-	-	"	-	-	Breech-loading Rifled Ordnance.
S.A.	-	-	"	-	-	Small Arm.
H.G.	-	-	"	-	-	High Gauge.
L.G.	-	-	"	-	-	Low Gauge.

It may be noticed that the weight of any projectile given under the head of "details of patterns" is generally the "standard weight," *i.e.*, the weight laid down as the standard for manufacture, from which the actual weight of no projectile is allowed to differ beyond the authorised limits of error. Failing this, as in the case of a pattern of very old date, the actual weight of the sealed pattern shell may be given, but this gives no certain accuracy, since the pattern itself may be incorrect within the allowed limits; in fact, where the "standard weight" is given, the additional mention of the actual weight has even led to mistake; for example, in Changes of War Stores, § 753, the mean weight of certain sealed patterns, viz., 96 lbs. 12 $\frac{3}{4}$ oz., has been quoted instead of 98 lbs., which lies midway between the limits 96 and 100 lbs. given two lines below, and which is really the standard weight, the former being only an accidental average of some samples of manufacture on which it is incorrect to build deductions; thus it would be wrong to object to a shell of 99 lbs. weight, because it departed from the weight of the patterns by over 2 lbs., for it would only differ from the standard weight by 1 lb., and would be between the limits 96 and 100 lbs.

PART II.

AMMUNITION FOR RIFLED ORDNANCE.

SECTION I.

A rifled projectile is one which is fired in such a manner that it rotates on a fixed axis. Such rotation equalizes the effect of irregularities of mass or surface and prevents any accidental revolution, and thus gives increased accuracy.

This rotation causes a certain constant deflection ; but from the fact of its being *constant*, allowance can be made for it, as in the case of the guns of the service breech-loading and muzzle-loading systems.

Various means have been adopted to give rotation. The ordinary method is by spiral grooves in the bore of the gun, which have such a hold on the projectile that it can only pass through the bore by revolving on its axis, so as to conform to the spiral of the grooves. The means by which this hold is given depends upon the system adopted.

A bore with spiral groove is termed a rifled bore, but rotation or rifling has been attempted in other ways.¹ For instance, a shot has been made somewhat of the form of a double cone, the two apices being the point and base; in the base cone deep grooves were cut with a spiral in one direction, and in the head cone in the opposite direction. Thus pressure of gas on the base in the first instance, and pressure of air afterwards on the head, tended alike to give the shot a certain rotation.

Many other methods have been tried which were futile or inconvenient, but it is quite unnecessary to enumerate them.

Under the head of grooved bores really come the systems depending on mechanical fits, for instance, Whitworth's and Lancaster's, for the hexagonal and oval bores are only grooved rifles "in disguise;" and the fact that each shot is made in one piece, instead of having studs fixed in it, though a striking difference in construction, and one which affects the practical working of the systems greatly, need not be discussed in a work that only attempts to deal with stores actually in the service.

It may here be noted that the Lancaster figured as the only rifled gun employed in the Crimean war in 1854-55, and in spite of the crude state of development of the system it performed some good service firing at long ranges ; and one of its shell, though made of wrought iron, was reported to have produced a wonderful effect on bursting in the upper tier of the Malakoff tower.

The Whitworth long competed with the Armstrong system, and has had strong advocates. Its chief achievements have been great range and accuracy, which were obtained at the sacrifice of other qualifications.

¹ I first saw rifled bronze guns tried at Shoeburyness in 1857, and supposed that rifling would always consist in a grooved bore into which the shot would fit or be forced to enter ; but I have lived to have my ideas extended, and to become acquainted with smooth bores that fired rifled projectiles, and rifled bores that fired smooth projectiles ; an eccentric cheese-shaped shot which was fired from a cheese-shaped bore, and spun vertically for ricochet ; and I have even seen a gun that was rifled *outside*, and was made to recoil through a sort of screwed ring which forced the bore to revolve—this was intended to impart rotation to the shot by friction.

In the American war considerable moral effect was produced by a battery of Whitworth guns.

Dealing, however, with systems that have been actually adopted, rifled ordnance must still not be necessarily supposed to possess elongated projectiles, for though our rifled cannon fire them without exception, the Brunswick rifled musket (still extant) fires a spherical belted ball; and hence it is well to notice that the advantage above mentioned, that is, the accuracy due to a fixed rotation, follows from the bare fact of a projectile receiving such rotation, and in no way depends on its proportions.

It is obvious, however, that the introduction of elongated projectiles would follow that of rifled bores, and indeed it is very doubtful if cannon would ever have been rifled were it not for the sake of firing such projectiles, for the advantage of such accuracy as might be given to a spherical shot would very probably be counterbalanced by the curved and irregular ricochet that rotation imparts to it, and the increased strain on the gun; and thus rifling being necessary for the employment of elongated projectiles, and such projectiles being essential to the success of rifled cannon, the two have become inseparably connected in the mind, so that the instance of the Brunswick rifle is almost required to remind one that such a union does not always exist.

Strictly speaking, it should be noticed that after taking the rifling no shot can be exactly spherical, and indeed, nothing depends on the sphericity of a rotating shot, so that the approach to such a form may be looked upon as a very arbitrary property.

To go back, however, to the simple question of rifling, certain peculiar advantages follow from the rotation of the projectile, causing it to present the same part to the front throughout its flight. Such advantages, however indirect they appear, are inseparably connected with rotation; they are as follows:—

1st. It becomes possible to make a much simpler percussion fuze, because it is only necessary to provide for action in one direction, in place of every possible direction.

2nd. Shells required to act towards the front in any peculiar way may have their bursting charge and metal placed with a view to this object.

Thus the Boxer shrapnel discharges its bullets to the front, and the Palliser shell has a heavy pointed head, which impresses its momentum on the shield it strikes without acting through the medium of the sides of the shell, which, breaking on impact, would rob the projectile of much of its effect.

This latter illustrates the advantage which may arise from collecting the weight at one part of the projectile, and although both the shells referred to are elongated, yet the conditions above noticed might exist in a rotating shell of any form. So, again, the centre of gravity may be brought to any desired part of the shell, and this is now an important feature in the construction of service projectiles.

The following advantages belong to the power of altering the form of rifled projectiles at will, the weight being supposed to be given, so that comparison is made between an elongated and a spherical projectile of equal weight:—

1st. The head¹ may be made of any desired shape, for penetration or flight. (For flight of elongated projectiles, *vide* Appendix).

¹ It will be seen hereafter that ogival heads of from $1\frac{1}{4}$ to $1\frac{1}{2}$ in diameter have come in for all the most recent patterns of all kinds of projectiles (case shot of course excepted).

2nd. The projectile may be elongated as noticed above, so as to give a diminished surface for any resisting medium to act upon; thus in flight velocity is kept up and the range extended, or on impact greater penetration is obtained.

3rd. Or, on the other hand, weight for weight, the same effect may generally be produced with an elongated projectile with a smaller charge of powder than a spherical one.

All these advantages are to some extent attained in the service with rifled ordnance, as compared with smooth bore.

4th. It follows, from the flight of an elongated projectile meeting with less resistance from the air and keeping up its velocity better, that at all but very short ranges the trajectory is flatter; hence the probability of hitting any ordinary object is greater. It may be noticed that the question of a flat trajectory is simply that of a high velocity, since all projectiles may be said to fall at the same rate; and the trajectory of one only differs from that of another by the relative horizontal space it describes.

Thus in a second any shell will fall nearly 16·1 feet, but one may have travelled 1,400 feet horizontally, and another only 1,000 feet; and hence the former will have the flatter trajectory.

5th. The power to vary the length of a rifled projectile enables all those for the same gun to be made of the same *weight*, and hence to require the same elevations with the same charge of powder. This obviously cannot be the case with spherical projectiles, which must be all the same *size*.

6th. Conversely it is possible to make a projectile specially heavy if required; for example, the double shell for the 7-inch gun and 7-pr. (*vide* pp. 73 and 95).

N.B.—If required a specially light projectile could be made. The only case where such a projectile could well possess any advantage would be at very short ranges, fired with a very high velocity, the destructive effect being as the weight multiplied by the *square* of the velocity.

Any variations in length should, however, be made without losing sight of the limits which give good shooting with the twist of the particular gun in question. As a rule the best shooting length with any service twist is from two to three calibres.

To recapitulate, it may be observed that the following advantages accompany the use of the service rifled projectiles, as compared with those of smooth bores:—

- 1st. Accuracy.
- 2nd. Simpler action of percussion or concussion fuzes.
- 3rd. Distribution of metal with a view to the requirements of each case.
- 4th. Power of making the head of any form desired.
- 5th. From the fact of the projectiles being elongated, greater range or greater penetration.
- 6th. Saving of powder.
- 7th. A flatter trajectory.
- 8th. All projectiles for each gun can be brought to the same weight.
- 9th. If required any gun may possess a specially heavy projectile.

The chief disadvantages are bad ricochet, increased complication and expense of manufacture, and liability to injury arising from the necessity of soft studs or a soft lead coat; also the increased strain on the gun, besides greater probability of jamming and injuring the bore. But above all one great objection exists with reference to the breech-loading projectiles, which is the necessity of the presence of detonating powder in every description of fuze; but of this more hereafter.

Recapitulation.
Advantages.

Disadvantages.

The systems of rifling now in the service are as follows :—

1. Breech-loading, Armstrong, polygrooved.
2. Muzzle-loading, Armstrong, shunt.
3. " Woolwich.
4. " French.

ARMSTRONG BREECH-LOADING SYSTEM.

The Armstrong breech-loading system adopted for the service in 1858, comprises 7-inch, 40-pr., 20-pr., 12, 9, and 6 prs., in each of which the breech is closed by a vent-piece supported by a breech screw, and the 64-pr. and 40-pr. guns whose breeches are closed by a stopper and wedge. The different methods of closing the breech only affect laboratory stores to a very limited extent as will appear hereafter.

In the Armstrong B.L. system a soft coated projectile is forced through a polygrooved bore, of such diameter that it can only receive it by the lands cutting their way into the soft coat.¹

The twist is in all cases rapid and uniform.

Windage is done away with, hence the accuracy is great, the projectile is detained in the bore until the force of the powder is more fully developed than where there is less initial resistance.

As might have been expected this system has been more successful with the smaller calibres than the larger, where the great difficulty of closing the breech effectually, becomes aggravated by a system which saves powder at the expense of increased strain on the gun; this question has affected the ammunition considerably, for it has been found necessary in some cases to reduce the weight, both of the projectile and charge.

It will be seen hereafter that the opposite plan has been adopted in the large muzzle-loading guns where the projectile is allowed to move directly forward at first, and rotation is gradually impressed on it after the gun has become relieved of the initial strain due to the inertia of the projectile, this being done at the expense of an increased charge of powder, since the gas presses on the shot in inverse ratio to the volume of the space in which it is generated (*i.e.* the portion of the bore behind the shot), and the same object is still further carried out by the employment of the pellet or pebble powder, which consumes more slowly than the rifle L.G. powder used in the breech-loading guns.

The chief evil, however, of absence of windage as to laboratory stores consists in the fact that besides precluding the use of any concussion fuze lit by flash, and acting by mechanical arrangement on graze, it is necessary to ignite time fuzes by a percussion arrangement, and this entails, if not increased danger, at all events increased complication and expense, for as will be seen hereafter, any percussion arrangement necessitates the presence of detonating composition with its attendant consequences of increased liability to accident, and to deterioration in store and transit.

There are certain advantages connected with the service of all breech-loading guns, which scarcely belong to this course; that of enabling any unconsumed matter left in the bore after firing to be readily seen, should, however, be mentioned, this especially applies to blank firing.

It is due to the breech-loaders to notice particularly the great accuracy mentioned above, which at the time of their introduction insured such

¹ The diameters of all B.L. lead-coated projectiles are as follows at body and back end respectively; 7" 7.036" and 7.0875", 64-pr. 6.43" and 6.4875", 40-pr. 4.78" and 4.835", 20-pr. 3.78" and 3.841", 12-pr. and 9-pr. 3.029" and 3.0705", 6-pr. 2.531" and 2.5705"; the calibres of the guns being 7", 6.4", 4.75", 3.75", 3" and 2.5".

good results in practice, that deficiencies or faults which might otherwise have been obvious to many, were so little allowed to exist, that for some time one single projectile (the segment shell) was held to be efficient as shot, common shell, shrapnel, and case.

The projectiles that are now in the service in connection with this system are as follows:—

B.L. PROJECTILES.

A. Shell.

B. Shot.

A. SHELL.

1. Segment Shell.

2. Common „

3. Shrapnel „ (Boxer's).

Shell.

Three kinds.

1. *Segment* (calibres, 7-inch, 64-pr.,¹ 40-pr., 20-pr., 12-pr., 9-pr., and 6-pr.) *shell* consists of a very thin cast-iron cylindro-conoidal shell, about $2\frac{1}{2}$ calibres long, lined with cast-iron segments, built up in layers, having a cylindrical powder chamber in the centre. The base is closed with a cast-iron disc.

Segment shell,
seven sizes.

A thin coat of an alloy² of lead extends from base to shoulder; the alloy also flows in between the segments and lines the powder chamber, giving great weight and solidity.

The shell is strong against external pressure, while a small bursting charge opens it.

The coat (generally termed the lead coat) was at first made of the following alloy: 8 parts soft lead to 1 part antimonial lead and 2 parts tin; but in June³ 1862 this was superseded by an alloy of 19 parts lead to 1 of antimony on the score of economy.

The lead coating is .05" deep over body, and .1" over base, a cannelure running round the shell to take any lead stripping off the front part.

Lead coating.

The increased diameter at base is intended—

1st. To prevent windage.

2nd. To enable the projectile to be gripped simultaneously at shoulder and base on ramming home.

3rd. To retain the grip until the base leaves the muzzle.

Uncoated portions (head and bottom) are painted black, the paint extending over the edge of the lead to prevent corrosion, &c.; one coat of common paint and one of Brunswick black being used.

Paint.

The lead coat has been attached in three ways:—

1st. By tin solder and square cut grooves in the shell. This stripped very much.

Attachment.

2nd. By mechanical means, viz., undercut grooves.⁴ This was better.

3rd. By zinc solder,⁵ no grooves.

The zinc amalgamates sufficiently with the iron and lead to give a very complete attachment. To compensate for the absence of grooves on the outside of shells with zinc attachment, similar grooves are cast on the inside, except in the 64-pr., which came in since the introduction of this attachment.

The 7-inch, 64-pr., and 9-pr. have also grooves running round the outside of the base and inside edge of the body; that is, in the surfaces

¹ Very few 64-pr. segment shells have been made; they were issued to Canada, and it is possible that they have all been expended or returned to Woolwich.

² For alloys used, *vide* below.

³ *Vide* Changes in War Stores, § 543.

⁴ Approved provisionally. Changes in War Stores, § 271.

⁵ Approved for higher natures (viz., down to 40-pr. inclusive) by Changes in War Stores, § 330.

of base and body which are in contact, for the lead to enter and seal up the joint.

Every segment shell has four longitudinal grooves in the interior of the head.

Classes.

Segment shell are of two classes—

1. Garrison.
2. Field.

Class 1, three sizes.

Class 1. Garrison.—7-inch, 64 and 40 pr. The shell has a gun-metal bush, .9 inch below the apex of the shell,¹ of Moorsom gauge, formerly taking pillar fuze (now obsolete); now taking Boxer's 9 or 20 sec. B.L.R.O. time or Pettman's G.S. percussion fuze, with an adapter².

It is closed with a gun-metal plug. The powder chamber opens abruptly with a sharp shoulder about 2.3 inches below the apex of the shell; it is lacquered with red³ lacquer to prevent premature explosion from friction of iron against powder, which in shells with rapid rotation is very great.

The approximate bursting charges of shell powder L.G. are as follows⁴ :—

7", 3 lbs. 2 oz.; 64-pr., 2 lbs. 12 oz.; 40-pr., 13 oz.

Class 2.
Field, four sizes.

Field (20-pr., 12-pr., 9-pr., 6-pr.) have the powder chamber nearly the same size as the fuze hole, being in continuation of it; the interior lead lining forms generally⁵ a slight shoulder sufficient to prevent the entrance of the head of the percussion fuze.

The 6-pr. chamber decreases at bottom, taking a special burster. This shell and the others, which take gas-pipe bursters,⁶ obviously do not require lacquer inside the powder chamber.

The 12 and 9 prs. are rounded at base to prevent enlargement from setting up in the limbers.

The fuze hole of every field service segment shell is cylindrical, tapped with a coarse left-handed thread, closed by a gun-metal screw plug with loop. It is not bushed; it takes the E or F time fuze with C percussion and burster. The time fuze, however, is withdrawn from the L.S. equipments (3/6/70 by § 1907, Changes in War Stores.)

The C percussion fuze may be dispensed with by placing the serge-covered wood plug carried over the burster in the shell beneath the same, so as to bring it close to the time fuze.

¹ This recess enables the pillar fuze, when screwed home, to have its crown .2" countersunk below the lip or apex of the shell.

² These adapters are now permanently fixed in the shells, being screwed in with red lead and fine hemp round the thread on the exterior, the space between the plain part of the adapter and the interior of the recess in the shell head being filled up with red lacquer. See p. 17, note ¹.

Instructions as to this operation are given in Changes in War Stores, § 1583; approved 18/2/63.

The adapter is to be filled with a plug of wood, and the lacquer poured in round it very hot. No special tools are required.

³ A black lacquer (hard coal tar pitch, two parts by weight; Swedish pitch, one part) introduced by the Elswick Ordnance Company, approved 17/1/62, has been much used in these shells, and may be found, although superseded by red lacquer, composed of—Rosin, 12 lbs.; Spanish brown, 2 lbs.; plaster of Paris, 1 lb.; turpentine, $\frac{1}{2}$ pint.

The black lacquer in shells returned after being on service is generally very rough, and occasionally detached in places (*vide* O.S. Committee Extracts, vol. iii., pp. 142 and 240), this lacquer being liable to run in hot climates, or even when the shell is exposed to a hot sun in England.

⁴ *Vide* Changes in War Stores, § 1116.

⁵ This is to prevent the C percussion fuze being inserted upside down, but this shoulder does not always exist. I have especially found it deficient in the 12-pr.

⁶ The gas-pipe bursters of present patterns, marked B.F. or B.C., contain the following quantities of "F.G." powder (or of powder closely resembling it obtained in the manufacture of R.F.G. powder), viz., the 20-pr., 700 grs.; the 12-pr., 550; the 9-pr., 300; the 6-pr. burster contains 200 grs. of the same.

The C percussion, screw pattern (ordered to be withdrawn), if met with may also be used with the same arrangement of burster, but neither of these plans should be adopted unless absolutely necessary, as the action of the shell becomes exceedingly bad from the burster being too far forward, and the base portion frequently fails to open.

With reference to distinctive marks indicating the peculiarities of each pattern, the most important is the numeral (*vide* Preface). This is stamped on the coat of B.L. projectiles made since the commencement of 1866. Distinctive marks.

Very large numbers of shells, however, will be found without any numeral, having been made previous to this date, and many of a pattern previous to that identified by Mark I.


As a rule, shells made at Elswick are marked on the heads, and Laboratory made shells on the bases; both may carry marks on the coats.¹

Shells for the service were at first made by the Elswick Ordnance Company. Such shells are generally marked E OC on the head, and if passed by the Inspector of Artillery, I \uparrow A on the coat,² besides the marks agreeing with the sealed pattern.

Shells made in the Royal Laboratory have R L on the base, and generally Z, indicating zinc attachment. A few have Z on the coat.

U on a lead coat signifies the undercut method of attachment,³ but many of the undercut shells (especially 20-pr. segment) and all shells with tin attachment are without any mark of this kind.

Shells with the lead and antimony coating, made in the Royal Labora-

tory, are marked  in the cannellure, a few have been made at

Elswick with the same coating, but there is no mark to indicate this. In some instances, as in the case of the so-called 70-pr., mentioned hereafter, the nature of the pattern would do so.

Marks which should be on coats are frequently found deficient.

All shells with I \uparrow A on the coat may be assumed to have lead and tin coats (the attachment may be tin, undercut, or zinc).

The details of the patterns of each calibre are as follows:—

7-in. Segment Shell.

The earlier patterns were made by the Elswick Ordnance Company, and it is difficult and probably unnecessary to obtain every particular connected with the first shells made and issued.⁴ Shell, rifled,
B.L. segment,
7-inch.

The weight of every existing pattern is about 98 lbs. (empty, without screw plug), each one is about 14.5" long, and is of the same general form, having a conoidal head terminating in a nozzle or lip round the

¹ Some E OC shell, re-led in Royal Laboratory, carry Laboratory marks on their coats.

² Approved 4/9/62. *Vide* Changes in War Stores, § 601. Some shells of very early manufacture have \uparrow only.

³ Approved 30/10/62. *Vide* Changes in War Stores, § 669.

⁴ The "Standard Weight" is that authorised to govern the limits of manufacture, which are taken with reference to it, generally $1\frac{1}{2}$ per cent. above and below; failing this, the actual weight of a pattern projectile is sometimes given, and where this is done, unless the contrary is stated, the weight given is its weight empty and without screw plug.

fuze hole recess.¹ The bottom is flat round the edge but slightly rounded in the middle.

The patterns deposited in the Royal Laboratory are as follows :—

1st. Sealed 21/2/61 with tin attachment and black lacquer, marked E OC on head and base, and 1 \nearrow A on coat; the coat even of the sealed pattern is loose in certain places.

2nd. Approved, 30/12/61²; undercut attachment and black lacquer, marked E OC, and A on head.

Pattern known
as mark I.

3rd. Approved, 30/12/61²; length, 14·48 inches; standard weight, 98 lbs. 9½ oz.³; capacity for bursting charge, 3 lbs. 2 oz. Zinc attachment and red lacquer. Marks on coat Z, also date of manufacture and I, on base R L.

64-pr. Segment Shell.

Shell, rifled,
B.L. segment,
64-pr.

Under this head, being intended for the same gun, must be classed,—

1st. The 70-pr. segment shell; approved, 14/2/63⁴; length, 14 inches; weight, 74 lbs. 9 oz. Of the same general form as the 7-inch segment, that is, with a bottom rounded in centre, and a head with a slight nozzle at the fuze hole. It has zinc attachment and black lacquer. Marks E OC on head.

Z

2nd. 64-pr.; approved, 19/6/65⁵; pattern in Royal Laboratory; length, 13·9 inches; standard weight, 62 lbs.³; capacity for bursting charge, 2 lbs. 12 oz. Bottom rounded in centre, no nozzle at fuze hole,

L

zinc attachment and black lacquer. Marks, on coat R \nearrow L, date and I,

A

on base R L.

40-pr. Segment.

Shell, rifled,
B.L. segment,
40-pr.
Details of
patterns.

The successful patterns of this shell have differed in little except lacquer and mode of attachment, each having been 10·6 inches in length, with conoidal head and flat base, the weight being about 39 lbs.

The following exist in the Royal Laboratory :—

1st. Approved, 21/2/61,⁶ with tin attachment and black lacquer, marked E OC and C on head.

2nd. Approved, 30/12/61,² with undercut attachment and black lacquer, marked E OC and C on head.

3rd. Approved, 30/12/61²; length, 10·62 inches; ⁷weight of sealed pattern empty, 38 lbs. 9½ oz.; ³capacity for bursting charge, 13 oz. Zinc attachment and red lacquer; marked Z and I on coat, and R L on base.

20-pr. Segment.

Shell, rifled,
B.L. segment,
20-pr.
Details of
patterns.

1st. Under this head must be enumerated a shell weighing about 25 lbs, introduced for the gun now called the 20-pr., it is now hardly to be met with.⁸ It is of the same general form as more recent patterns, differing mainly in length and weight; no sealed pattern of it exists at Woolwich. It is declared obsolete by Changes of War Stores, § 1815, and ordered to be returned to Woolwich for breaking up.

¹ The curve of the head is struck with three radii occasionally, and there is so much variation in the radii employed in different patterns, that it would be useless to go into the details of each form.

² Vide Changes in War Stores, 405.

³ " " " 1116.

⁴ " " " 723.

⁵ " " " 1086.

⁶ " " " 211.

⁷ The standard weight is given as 38 lbs. 9 oz. 11 drs.

⁸ H.M.'s. Ship "Niger" returned two of these shells into store at Woolwich in the end of 1868.

2nd. Approved, 17/12/61,¹ pattern in Royal Laboratory ; standard weight, 19 lbs. 10½ oz. ; length, 8·16 inches, undercut attachment. For probable marks, *vide* general remarks, viz., E OC on head, and 1/Λ on coat.

3rd. Approved, 9/5/63,² sealed pattern in Royal Laboratory ; length, 8·1 inches ; standard weight, 19 lbs. 10 oz. Conoidal head, flat bottom, zinc attachment. Marks, on head $\begin{smallmatrix} E & OC \\ & Z \end{smallmatrix}$ and E, on coat I.

12-pr. Segment.

The first circular extant is 639, par. 90 ; approved, 13/4/60³ ; standard weight, 10 lbs. 9 oz. ; beading on head low down and indistinct, cannellure 1·9" from base, contains no small segments in head ; now issued for practice only.

Shell, rifled,
B.L. segment,
12-pr.
Details of
patterns.

2nd. 17/2/61.⁴ No sealed pattern extant. Standard weight, 10 lbs. 8 oz.

3rd. Approved, 30/12/61.¹ Pattern in Royal Laboratory prepared at Elswick. Length, 6·65 ; standard weight, 10 lbs. 6¾ oz. Conoidal head, flat bottom, undercut attachment. Marks, on head, E OC and Q.

4th. 9/5/63.² Pattern in Royal Laboratory. Length, 6·75 inches ; standard weight, 10 lbs. 8 oz. Conoidal head and flat bottom, it has zinc attachment. Marks on head, E OC and Q.

N.B.—There is no Z on the coat or head of the pattern shell.

5th. 28/12/64.⁵ Pattern in Royal Laboratory. Length, 6·75 inches ; actual weight of pattern, 10 lbs. 6½ oz. Conoidal head, flat bottom

slightly rounded at edge (*vide* page 12). Marks on coat $\begin{smallmatrix} L \\ R \nearrow L \\ A \end{smallmatrix}$ and date, also I, on base $\begin{smallmatrix} Z \\ R L \end{smallmatrix}$.

9-pr. Segment.

The four following patterns are recorded as having been approved :—
1st. (No record of approval). Sealed pattern received in Royal Laboratory, 11/11/62 ; length, 5·4 inches ; weight, 8 lbs. 3¾ oz. Conoidal head, flat bottom, undercut attachment. Marks on head, E OC and V (some shells have T). This shell is issued for practice only.

Shell, rifled,
B.L. segment,
9-pr.
Details of
patterns.

2nd. Approved, 29/5/62.⁶ (No sealed pattern extant), prepared in Royal Laboratory. Length, 5·35 inches ; conoidal head, flat bottom, lead and antimony coat with usual Laboratory marks.

3rd. Approved, 9/5/63.² Pattern in Royal Laboratory. Length, 5·4 inches ; standard weight, 8 lbs. 5 oz. Conoidal head, flat bottom, zinc attachment. Marks on head, E OC and V, there is no Z on coat or base of sealed pattern.

4th. Approved, 28/10/64.⁵ Pattern in Royal Laboratory. Length, 5·4 inches ; weight, 8 lbs. 3¾ oz. Conoidal head, flat bottom with

rounded edge, zinc attachment. Marks on coat, $\begin{smallmatrix} L \\ R \nearrow L \\ A \end{smallmatrix}$, date, and I, on base $\begin{smallmatrix} R L \\ Z \end{smallmatrix}$.

¹ *Vide* Changes in War Stores, § 405.

² " " " 754.

³ " " " 90. For practice only, by a recent order.

⁴ " " " 210.

⁵ " " " 1001.

The standard weight is not laid down, and owing to the rounding of the base, the shell may be generally of rather less weight than the previous pattern.

⁶ *Vide* Changes in War Stores, § 542.

Shell, rifled,
B.L. segment,
6-pr.
Details of
patterns.

6-pr. Segment.

All the known patterns of this shell are of one form, viz., conoidal head and flat base; length, about 5 inches; weight, about 5 lbs. 6 oz.

The following patterns exist:—

1st. Approved, 3/7/61.¹ Pattern in Royal Laboratory made at Elswick. Standard weight, 5 lbs. 9 oz.; tin attachment, no marks of any description on the pattern.

2nd. Approved, 30/12/61. Pattern in Royal Laboratory made at Elswick; tin attachment, no marks on pattern, and no groove round the junction of head and body.

3rd. Approved, 30/12/61.² Pattern in Royal Laboratory made at Elswick. Standard weight, 5 lbs. 6 oz.; undercut attachment; no marks on pattern.

4th. Approved, 9/5/63.³ Pattern in Royal Laboratory, made at Elswick. Standard weight, 5 lbs. 7 oz.; zinc attachment. Marks on head $\begin{smallmatrix} \text{E} & \text{OC} \\ \text{Z} \end{smallmatrix}$ and E, on coat I.

Paint.—The uncoated portions, viz., the head and bottom are painted black, one coat of common paint and one of Brunswick black being used. The paint extends over the edge of the lead so as to prevent corrosion at the junction of the two metals.

ISSUE OF SEGMENT SHELL.

1st. Filled.

1st. *Filled.*

7" and 40-pr. segment shells have been issued for sea service,⁴ fuzeed with pillar percussion fuzes;⁵ all shells so issued since 27/10/66 were marked "Filled" in red letters.^{6 7 8}

All filled 7" and 40-pr. segment shells issued since 5/8/67 would

¹ *Vide* Changes in War Stores, § 344.

² " " 405.

³ " " 754.

⁴ Changes in War Stores, No. 6, new series, § 1089, 16/6/65. Elongated shells are in future to be issued to H.M. ships, without boxes, filled and fuzeed, provided the fuzes are percussion and recessed in the nose of the shell.

⁵ All filled shells with pillar fuzes are to be considered dangerous. The detonating composition of the pillar fuze is immediately beneath the slot in the head, hence there is great risk of using force with a key.

The following is the safest way of dealing with filled shells with pillar fuzes in them.

Should there be a large number either procure or make a gun-metal extractor (*i.e.*, gripper) to enter the recess and grip the pillar fuze round the head without touching the top of it.

In every case of a fuze not yielding readily to such an application of force, or in the case of one showing signs of violent treatment such as slot injured, or crown bent, or in the case where there are very few shells to deal with and no proper extractor, it is better to dispose of them safely, for instance, take them out to sea and throw them overboard, or where this cannot be done place the shell under water, and in that situation drill a hole in the side so as to drown and remove the bursting charge. *Vide Army Circular*, 1/11/69, given in Appendix, clause 143, §§ 1, 2, 6, 7, 8, 9, 10, 12, 20, 21, 22, 23, 25, 29, 30, &c. (The results of the operation given on § 24 will seldom be found to pay for its performance.)

⁶ This marking is liable to be covered with a fresh coat of paint, given to the shells on board ship.

⁷ Changes in War Stores, § 1349, 27/10/66.

The word "filled" is to be painted on all filled shells when issued loose or in boxes for transit, for ready identification.

⁸ Filled or empty B.L. shells might be sent in boxes, if convenient for transit.

have G.S. adapters fixed in the fuze hole,¹ being fuzed with Pettman G.S. fuzes, and being marked "Filled" in red.

²All filled in the Royal Laboratory since 24/3/70 would have the date and R/L and W also in red. 12 and 9 pr. filled B.L. shells are issued to the navy in boxes marked in the same manner as the filled shell with red paint.³

2nd. Empty.

7", 64 and 40 prs. for L.S., and 7" and 40-prs. for S.S. were formerly issued with screw plug, Moorsom gauge. Since 5/8/67 all such shells would have adapters fixed in the fuze holes and G.S. screw plugs, and since 30/11/66 such as are issued for S.S. have had blue waxed wads⁴ in the recesses over the fuze holes to distinguish them more readily from filled shells; "kit plasters"⁵ to cover fuze holes of empty shells were approved 28/2/66, but no shells were so issued.

3rd. Issued Filled or Empty, but afterwards commonly filled.

12-pr. and 9-pr. segment shell are issued filled for S.S. in special boxes,⁶ they are marked in red "filled" &c. as above.

20, 12, 9, and 6 prs. are issued empty with screw plugs with string loops but are commonly filled afterwards,⁷ that is, the iron bursters with serge covered wood plugs over them, are inserted in the shells and screw plugs closed down on them. These shells therefore must be assumed to be filled when carried in limbers, and the word "Filled" must not be looked for on them at any time.

N.B.—Jute bags are placed on shells sent to India to protect the lead.

Segment shell has been used as shot, shrapnel and case, if not also as common shell; great accuracy of fire was obtained. As shrapnel, however, the position of the bursting charge causes it to disperse the segments greatly, already predisposed to scatter from the centrifugal force due to the rapid twist, and it should therefore be burst as close on to the object

3rd. Filled or empty, but afterwards filled.

Use.

¹ Changes in War Stores, § 1238, approved 29/6/66.

"Existing shells will be fitted with special adapters permanently screwed in. New shells will be completed with the G.S. bush," &c. also.

Changes in War Stores, April 1868, § 1583, approved 18/2/68.

"Apply a coating of red lead to the screw part of the adapter, and screw it home. After screwing the adapter into rifled shells, fill the space between the plain part of the adapter and the nose of the shell with the following composition:—

Rosin	-	-	12 lbs.
Spanish brown	-	-	2 "
Plaster of Paris	-	-	1 lb.
Turpentine	-	-	$\frac{1}{2}$ pint.

The composition should be poured in whilst very hot, a plug of wood being fitted into the adapter to prevent any of the composition running inside. No special tools are required."

² Changes in War Stores, § 1880, directs that filled shells are to be marked in red with the date of filling, and monogram or letter of the station where filled; when packed in boxes, the boxes to be also similarly marked. Shells filled on board ship are to be marked with the word "filled" and date of filling in white. For monogram or initial, *vide* Changes in War Stores, § 1633.

³ No more special boxes are supplied for this purpose except for 12 and 9 pr. segment. *Vide* Changes in War Stores, § 1588.

⁴ Approved 30/11/66. *Vide* Changes in War Stores, § 1346.

⁵ " 28/2/66. " " " 1190.

⁶ " 25/1/68. " " " 1588.

⁷ This has always been done, but if authority were needed, Changes in War Stores, § 1581, would give it.

as possible. The segments also, from their form, lose velocity rapidly and on grazing are apt to lodge in the ground.

The last objection holds good against its use as case, whilst as shot it is intricate and expensive.

From the above it may be seen that the effect is very local; the best result as compared with shrapnel is obtained when firing with percussion fuzes to burst close on the object, when the large cone of dispersion can be turned to the best account, this may be done on very hard flat ground, or more especially at men crowded together under some cover or screen, such as the thin wall of a building, which is sufficient to cause the percussion fuze to act without preventing the shell from penetrating it.

EXPERIENCE WITH SEGMENT SHELL.

Shooting on Active Service.

Most of the reports on the segment shell in active service have been favourable.

In New Zealand it was spoken of as very valuable in searching out men in rifle pits.¹

¹ Extracts from Report of Capt. Mercer, R.A., to D.A.G., R.A., 6/4/61. See R.A.I. Proceedings, vol. ii., page 393:—

"The guns were loaded and laid, and the gunners with lanyard in hand waited for the word from the officer, who was watching until some heads appeared above in that direction, or a puff of smoke revealed their presence, when the gun was instantly fired, and the shell, entering just below the crest of their pits, burst inside.

"The following evidence has been given concerning the action of the Armstrong shell with the concussion fuze (*i.e.*, percussion fuze) only:—Colour-Serjeant J. Morant, Royal Engineers, was at the head of the sap, and saw an Armstrong shell go through a rifle pit, about four feet of earth, and burst inside, and heard the enemy shout as in pain; he also observed that the shell from the Armstrong gun entered the rifle pits as soon or sooner than the report was heard, so that the natives had not time to get out of the way. Bombardier J. Singer, No. 3 battery, 12th brigade, R.A., was at the head of the sap, and in the advance parallel with the Coehorn mortars, when he saw several shell from the Armstrong gun go through the enemy's rifle pits and burst inside. After the cessation of hostilities one of the natives told my serjeant-major that they were sometimes able to get out of the way of the mortar or large shells, but never out of the way of the shell (whether with time and concussion, or concussion fuze only) from the gun 'all the same as the rifle,' meaning the Armstrong guns, as the shell was amongst them as soon as they heard the report. These natives have designated the Armstrong shell 'the quick shell.'

"The different statements made both by those who were in the sap as well as by the natives themselves corroborate the observations taken from the battery, viz., that the Armstrong shell with concussion fuze only entered the crest of the enemy's rifle pits and burst inside; whether there were few or many natives in the pit at the time cannot be ascertained."

Extracts of Evidence given by Captain Seymour, C.B.R.N., before Armstrong and Whitworth Committee, page 74.

"Saw the Armstrong guns worked in New Zealand the whole time, and almost every shot that was fired from them.

"I have seen a report by Captain Mercer of the Royal Artillery, who commanded the Armstrong battery, and I am only expressing the feelings of the officers and men of the three regiments of the line and of the naval brigade engaged there when I say that we by no means concur in Captain Mercer's statement in his report. We were all most anxious for the success of the Armstrong principle; we had also heard of what it had done in China, but I cannot say that the practice was as satisfactory as we hoped it would have been, I mean from the 12-pr. 8 cwt. guns. Captain Mercer succeeded to a certain extent in driving shell through the earth so as to burst with the concussion fuze inside the rifle pit."

In China it was especially praised for its action when fired with percussion fuzes to burst through brickwork.¹

Its accuracy has been much commended,² also its range,³ these being

¹ *Extracts of Evidence given by Captain R. Harrison, R.E., before Armstrong and Whitworth Committee, p. 69.*

"The shell from the Armstrong guns in China were very destructive. By one shot that was fired at an action that we had near Pekin I think there were as many as 13 killed. It was at a very long range (about 1,500 yards), and there were two or three horses, and, I think, 13 men killed at one single shot. The effect was produced by a segment shell with concussion fuze. It was not hilly ground, but ground dotted over with small jungles and villages, comparatively level; there were deeply sunk roads and gullies here and there. You could see a good deal over the country if you got on the top of a little mound or of a house. The shell struck in a roughish field, not hard ground, it was dryish ground. This one shot was very much noted, because we had been fighting with the Tartars all the day, and they had halted in a place which they thought was quite out of range. Then Sir Hope Grant said he wanted to try the effect of one shot at them, and he ordered one gun to be fired, and the effect was very striking. Everybody was surprised, and the Tartars particularly so. There was a large body of 500, I should think, and it completely dispersed them. That was the most remarkable shot I witnessed against men, and we all noted it. The chief effect that I saw with Armstrong guns was against the village of Tang Ku. That was a large fortified village. The guns were all brought up in line, and at a range of from 1,000 to 1,200 yards, opened against the guns of the enemy. There were about 60 enemy's guns firing on the Armstrong batteries and the other batteries which were brought up in line, and I noted where the Armstrong guns fired. There was a battery of Armstrong's on the right. There were 16 or 18 gunners of the Tartars killed at one gun. The shells hit a small crenelated wall on the top of the parapet, about 3 feet 6 inches high and 1 foot 3 inches to 18 inches in thickness where they burst, and soon all the Chinese gunners were killed. We counted at one gun from 16 to 18 bodies. The effect was very destructive against those men who were concealed behind this parapet. The parapet was just sufficiently thick to explode the shells. We saw where the shell struck the parapet and broke, that the men were all killed by the Armstrong shell. There were some, of course, in the line that were killed by other shell, but the ones that I noted were killed by the Armstrong shell.

"Certainly the Armstrong guns, we all thought, were terribly effective, and they saved a great deal of loss on our side. Photographs were taken showing how the bodies lay about inside. There were an immense number killed by the Armstrong guns. I am quite sure that the great impression in the army was that almost all the effect thus produced on the fort, as well as on the village of Tang Ku, was by the Armstrong guns. I am sure that the wounds were caused by Armstrong guns. I saw the segments of the Armstrong shells lying about just inside the casemates, and the wounds, you could see, were made by them. Sometimes you found a bit in the wound; you cannot mistake the wound."

² *Extracts from Captain, now Colonel, Milward's Notes on Armstrong 12-prs. on Service in China, p. 214. Select Committee on Ordnance, 1862.*

"11th August 1860. In action at Singho. The battery fired an average of 18 rounds per gun at 1,200 and 450 yards, besides two shells at 2,100 yards, all with most excellent effect. The concussion fuzes acted admirably; the practice was entirely against cavalry in open order, and quite prevented their forming for a charge, which they attempted more than once. The effect of the shells was all that could be desired. The two fired at 2,100 yards, dispersing a large body of cavalry instantly.

"18th August. Fired 30 rounds per gun, 25 time fuzes, remainder concussion. Time fuzes did not succeed. The concussion fuzes acted well, but one burst in ramming home. No damage to the gun.

"21st August. Capture of Peiho forts. Fired 85 rounds per gun, all with concussion fuzes, making excellent practice at various ranges from 1,600 to 400 yards. The practice at one of the south forts at a range of 1,200 yards was most excellent, several shells in succession bursting on the terreplein of the cavalier. The firing at the north fort at 1,600 yards was also very good, and most effective. Some shells have been picked up only partially burst; generally, I hear (I have only seen one)

[cont.]

³ See next page.

of course exhibited in a marked degree when compared with its spherical predecessors.

the bottom half of the shell is unbroken. The concussion fuzes are also liable) to suffer from damp, but can be easily repaired if time permits."

Captain, now Lt. Col., Hay, R.A., B.M. to R.A. in China. Extracts from his Report to Brigadier-General Crofton, R.A., 6/9/60, p. 216. Select Committee on Ordnance.

"Those (Armstrong shell) that struck the parapets in places where more than three feet thick, appeared to be blind, whilst the others passed through scattering their segments on the other side.

"On our first advance from Pehtang I assisted in laying the gun on bodies of cavalry, at distances varying from 1,600 yards and upwards, and found that those that burst as desired were most efficient. The same day I had also an opportunity of seeing the gun fired at very long ranges, viz., about 2,700 yards; this was at an enemy retreating at Sinho along a narrow causeway; only one shell that I observed burst at that range; they grazed well. I observed in many instances that the shells had not broken into segments, but had broken in two, or the head or bottom was merely blown out; they (the segments) certainly at present do their work, as, although I found many dead, I never found a man wounded by a segment, they appear to pass right through, stopped by nothing."

Concussion fuzes, a great number were blind. * * * I also observed some premature explosions with them, which must have done some mischief to our troops.

³ [Referred to on page 19]:—

Extract from Remarks of Lt. Pichard. R.A. Vol. 4; Proceedings of R.A. Institution, p. 371.

"From these plans and descriptions two sections were constructed, one of which similar to the pahs constructed in the northern part of the island, consisted of two rows of young trees, or strong spars, about 18 inches in diameter placed upright side by side from 8 to 10 feet high in the clear, the rows being about 3 feet apart.

"The other description of pah consisted of strong spars about 18 inches in diameter, placed upright in the ground about 8 feet apart; cross bars connected them, and on these were hung smaller spars from 4 inches to 6 inches in diameter; these were placed close to one another, and their ends were kept about a foot above the ground. No nails were used, but as is customary with the natives, flax secured everything. The line of stockading was again double. The natives used to fire out of pits dug out behind the second row, and made deep enough for them to fire under the stockades.

"These latter pahs were used by the southern natives in the war of 1860-61, and on one occasion one 8-inch gun and two 24-pr. howitzers, besides a 9-pr. gun, failed to make a practicable breach in a pah formed as above stated, after two hours' firing, at a distance of 200 yards.

"The battery of six 12-pr. Armstrong's took up a position 900 yards from the stockade, and after rather more than an hour's firing made a breach, in the section constructed after the northern fashion, large enough to allow a section of men to go through abreast.

"The southern description of pah was more difficult to breach, as it gave more to the shell on bursting; and the debris, supported by the flax, was most difficult to clear away. With both descriptions of pahs, salvoes were found most effective, all the guns being laid on the same part of the stockade, until the posts which seemed to afford most support were destroyed.

"The great accuracy with which these guns could be fired, and the tearing damage done by the shells on bursting contributed greatly to effect a breach in the latter description of pah. About two hours were employed in making a practicable breach, and concussion fuzes were chiefly used.

"The guns at Whangamarino then annoyed the Maories at Mere-Mere as much as possible. It was found that the best way to damage canoes at great distances was to fire shells with concussion fuzes, to strike rather short of the canoes, the shell burst on striking the water and the pieces ricocheted forward among the canoes. It was found also that by firing with time fuzes fixed to burst at the extreme range of the fuze, the pieces of the shell all went over 2,600 yards if the gun was laid with about half a degree more elevation than the actual range required. The shells thus fired burst high in the air, and the pieces being propelled forward and downward went to a great distance.

"When the assault was ordered the rapidity of fire was increased, shells had been prepared in expectation of the assault, and the guns were loaded as fast as they were fired.

"The shells burst beautifully and prevented the Maories taking any aim at the advancing troops, but, when from the near approach of the storming party to the works, the shelling was stopped, the soldiers suffered severely.

Some failures and dangerous accidents occurred with percussion fuzes, and some segment shells failed to open properly (noticed in notes below).

SHOOTING, HOME SERVICE.

Its action has been investigated by the Armstrong and Whitworth Ordnance Select and Dartmoor Committees, this being done in comparison with the Boxer shrapnel shell.¹

It would indeed be difficult to sum up concisely and impartially the results of all these experiments, or to select extracts from the proceedings of the committees; however, the following statements will hardly be contradicted. The shrapnel bullets form a smaller "cone of dispersion," that is, carry much closer than the segments, and hence the shrapnel is effective when burst at a much greater distance in front of the object² than the segment shell; it allows of wider limits of error

"When a long range or great precision is required, the Armstrong shell is most effective, but it would fail if used as a substitute for a howitzer shell in breaching field parapets, and in ricochet fire at short distances."

¹ Vide extracts from Proceedings of Ordnance Select Committee, report of Armstrong and Whitworth Committee, and report of a Select Committee on Ordnance, House of Commons, reprinted together in 1869.

² *Report of Armstrong and Whitworth Committee given on page VI.*—After a careful consideration of this practice the Committee have to report that when the shells are burst at only 10 yards in front of the targets, the concentration of the fragments with all the guns is greater than is desirable when fired against troops in line, almost the whole effect having been produced in each case upon a front of 18 feet. Where the shells were burst at 25 yards the distribution was better, and the effect of the three guns was about equal when fired against troops in line, but when burst at 50 or 100 yards in front of troops in line, Col. Boxer's shrapnel shell has a marked superiority, due to the bullets maintaining their velocity and direction better than the segments of Sir W. Armstrong's shell.

When fired with the time fuze at columns of troops, the greater penetration of the bullets of Col. Boxer's shrapnel shell make it a much more formidable projectile than Sir W. Armstrong's segment shell.

Ordnance Select Committee Report, No. 4,190, Minute 18,928, 8/6, 66.—"The result of this comparison (i.e. a comparison of 12-pr. shells burst in air at rows of targets) is much in favour of Col. Boxer's shrapnel shell, in respect to the total number of balls and splinters striking the targets. This is in some measure accounted for by the actual number of segments being less than that of bullets in the proportion of 48 to 70, but making allowance for this, the proportional number is still greater at every distance.

"Reviewing the whole of the experiments with the 12-pr. gun, the Committee are led to the conclusion that if the segments in the segment shell were reduced in size and increased in number, to equal the number of bullets in the shrapnel shells, the latter would have no great advantage when burst in air by a time fuze at short distances from a line of troops; but would still possess a material advantage when burst between 20 and 100 yards in advance.

"The foregoing results (i.e. of 64-pr. shells burst through screens placed at varying distances in front of rows of targets) exhibited very marked superiority in the shrapnel shell when burst in the air by a time fuze at a suitable height and at any distance within 200 yards of the targets."

Ordnance Select Committee, Minute 22,108, Report No. 4,602, 20/5/67.—Further to elicit the full merits of the shrapnel, a few rounds of each of the M.L. calibre under trial were fired through screens so placed as to burst the shells at distances varying from 250 to 300 yards short of the targets, or in other words, at distances known to be unfavourable to the effect of the shell, although within the limits of variation which might occur in actual service, from the difficulty of accurately judging distances, and the amount of error which may reasonably be inspected in elevating the gun, combined with the errors incidental to all time fuzes.

The results of this practice are most satisfactory, and afford conclusive evidence of the formidable nature of the shrapnel shell. It is apparently most effective when burst within 100 yards of the target, and at about 10 feet above the plane, but its efficiency in the larger natures is still retained even when the burst takes place at so great a distance as 300 yards short of the objects, a condition which the Committee believe would not be realised by projectiles constructed on the segment principle.

in setting the fuze,¹ the bullets have also a decided advantage in penetration,² and it will hardly be denied that they are a better form for flight and ricochet.

On the other hand when bursting quite close on the object, the wide spread of the segments tells well.³

A further experiment on a small scale was also made in April last, to elicit more fully the relative merits of 7-inch B.L. shells on the shrapnel and segment principle of construction, the special object being to ascertain how far the segment shell would be effective, if the burst did not take place comparatively close up to the object aimed at. On this occasion the shells, both shrapnel and segment, were burst artificially on a wooden screen, placed at 55 yards distance from the front row of targets. Unfortunately it so happened that the two segment shells which struck the screen burst under unfavourable conditions; the results therefore cannot be taken as decisive of the relative merits of the two projectiles; still, the absence of effect from the segment shell shows that the segments are too widely dispersed for efficiency against troops in column, unless the shell be actually burst close up.

The Committee are, therefore, prepared to recommend that, in future manufacture, shrapnel be substituted for segment shell, for 7-inch and 40-pr. B.L. guns.

¹ In the Dartmoor experiments on Friday, 18th June 1869, three segment shells bursting from 40 to 45 yards in front of a row of targets, gave altogether only two throughs and one strike.

² *Ordnance Select Committee Report, No. 4,190, Minute 18,928, 8/6/66.*—In respect to penetrative powers, it appears, on examination, that the proportion of bullets, segments, and splinters which penetrated 2-inch deal targets, was as follows:—

	Shrapnel.			Segment.		
	Total Effects.	Through.	Per cent.	Total Effects.	Through.	Per cent.
Bursts by passing through first row of targets - - - - 4	496	382	0·77	(3 rounds.) 233	110	0·47
Burst by passing through the screen 15 yards in front of first row - 5	913	696	0·76	549	298	0·54
Do. 55 yards in front - - 5	458	314	0·69	128	60	0·47
Do. 105 yards in front - - 5	258	144	0·56	45	14	0·31

Notwithstanding therefore the less weight of the bullets than of the segments a larger proportion of the former penetrated 2-inch deal boards than of the latter.

³ The Committee have to observe that this practice, *i.e.* grazing on sand to act on three rows of targets took place on the level ground at Shoeburyness, which presents more favourable conditions for such practice than would generally be met with on service. It appears from it, that Col. Boxer's shrapnel shell, as fired from Mr. Whitworth's gun is far inferior to Sir W. Armstrong's segment shell when burst by grazing on the ground, both as to the number of fragments which hit and their distribution, but the Committee observe that, even under the most favourable conditions when burst by grazing more than 50 or 60 yards in front of troops, their effect is comparatively small, thus showing the importance to be attached to a good time fuze, and that it should invariably be used with these shells in the field in combination with the percussion fuze.

Upon reviewing the whole of the practice with Sir W. Armstrong's segment and Col. Boxer's shrapnel shells, and taking into due consideration the fact that the principle of the shrapnel shell is not confined to the form of shell used in the Committee's experiments, but may be applied to any form of projectile, also that the description of fuze best adapted for ricochet practice may be used with it, the Committee are of opinion that the shrapnel shell is the more formidable projectile of the two.

Vide Report of Armstrong and Whitworth Committee, Segment shell v. Shrapnel.

These results, *i.e.* obtained with percussion fuzes acting on graze at, from 9 to 60 yards in front of targets, show that the segment shell is very considerably the more reliable when burst on graze a very short distance in front of the object aimed at, and confirms the conclusion arrived at in this respect by the Armstrong and Whitworth Committee, although that body on the whole preferred the shrapnel construction.

In short the action of the Boxer shrapnel is rather adapted to time fuzes, and that of the Armstrong segment to percussion fuzes exploding close on the object, hence it will generally be found that the defenders of the segment shell advocate the use of the latter description of fuze, and those of the shrapnel the former.¹

The very serious evil of premature explosion has frequently occurred in segment shells, (as at Dartmoor). If the time fuze is not screwed

"In that case, however, (viz., on increasing the number of segments) the effects on graze would be still more in favour of the segment shells, and this is the use to which the Committee contemplate segment shells being principally put on moderately level ground.

"This comparison, i.e. of shells bursting on graze at, from 0 to 108 yards in front of a line of targets confirms the conclusion deduced from the 12-pr. practice, viz., that Col. Boxer's shrapnel shells are generally very inefficient when burst with percussion fuzes.

"The 64-pr. segment shell with its present large charge is also very indifferent, unless when quite close up, and absolutely useless when burst on graze at more than 50 yards distance." *Vide Ordnance Select Committee Report, No. 4,190, Minute 18,928, 8/6/66.*

At Dartmoor, the most wonderful success of the 12-pr. segment was on 2nd July against targets in column, when 10 effective rounds gave 529 throughs, 234 lodges, and 431 strikes; total 1,194. Ranges 1,670 yards. On this occasion every effective shell burst within 10 yards in front of a target.

¹ "The segment shell should be used only as a percussion shell where the range is unknown; the burst on graze gives a valuable datum to judge by.

"The shrapnel on the contrary should be used when the range is tolerably well ascertained and steady deliberate fire required. The fact of having to judge of the range by the burst in the air rendered it necessary to be deliberate in its use. Rapidity of fire from a single gun may appear to be very important, but the steady and continuous fire of a battery, or of several batteries together, render the difference of a few seconds of time with each individual round of less practical importance." "Remarks by Gen. Wilmot, commandant of School of Gunnery." *Vide Ordnance Select Committee Report, No. 4,862, Minute 24,005, 10/1/68, §§ 2, 3, 5, 8, and 2nd of 10 of opinion of (Dartmoor) special Committee on Shrapnel v. Segment shell which deal with this matter, are as follows:—*

It appears to the Committee that the segment shell with the percussion fuze, has, on the whole, given far greater results per effective round, as well as for the total number of rounds fired, than the shrapnel with the wood time, or the segment shell with time and percussion fuzes; and that in the special comparison of the shrapnel with percussion fuze, and segment with percussion fuze, the latter has a superiority.

Considering, therefore, the segment shell when used as a percussion shell and under circumstances favourable for the action of its fuze—such as on columns of infantry, against cavalry, abattis, buildings, &c., to be a most formidable projectile, the Committee are of opinion that as a percussion shell it should be retained in the equipment of field artillery.

On comparing the number of "effective" rounds with the number of rounds fired, it will be seen that the shrapnel has greatly the advantage, in consequence of its fuze being more reliable than that of the segment. The bullets of the shrapnel also range further, and are more destructive at longer distances from the burst than the segments of the segment shell; its fuze, too, is more easily manipulated than the E or F fuzes. Therefore, at unknown distances, and as the rapidity of fire increased, or in other words, the conditions of actual service were approached, the shrapnel proved itself decidedly superior as a time shell to the segment, and would still be so were even a perfect time fuze made for the latter. To recapitulate, the Committee attribute the superiority of the shrapnel as a time shell to the two following causes, viz.: I. The greater permissible error in the distance of its burst from the target. II. The great reliability of the wood time fuze. And considering that it is essential in the equipment of any field artillery to have an efficient time shell, they recommend the adoption of the shrapnel for this purpose.

The Committee therefore recommend,—

1st. The retention in the service of the segment as a percussion shell, conditional upon a reliable percussion fuze being provided for it.

2nd. The introduction of the shrapnel as a time shell, to be used with the Boxer wood time fuze.

3rd. That in the future equipment of field artillery, the proportion of shells should be 40 per cent. of shrapnel to 60 per cent. of segment.

home so as to press on the percussion fuze and burster, premature explosion may follow, and as such accidents occurred at Dartmoor particularly in independent firing, and especially with one battery, it is difficult to divest oneself of the idea that this may have been one cause, in one instance 9, and another 10, prematures occurring out of 27 rounds.

The Armstrong C percussion fuze is probably less liable to cause premature explosion in shells than Freeth's or Dyer's judging from Dartmoor and other experience; reasons for this are given hereafter, but its action is slower than that of the Freeth fuze, and shells seem more liable to split on hard ground and break up without bursting.

EXPERIENCE.

Stripping (on active service).

Stripping on
active service.

Complaints have been made of lead coated projectiles stripping in such a manner as to render it dangerous to fire over the heads of troops;¹ this objection, however, was made against shells with tin attachment, and can hardly apply to undercut or zinc attached shells.

With the zinc, although it is the best method, the coat has occasionally become detached in spots where the lead has risen up into blisters from the formation of gas underneath it.

Such blisters are generally very small, and may be pricked and then hammered down, when they will in no way affect the fitness of the shell for service. If left to develop themselves they have been known to attain a large size.²

As has been noticed before, a place on a shell where the coat is detached is detected by the flat double sound heard on tapping it, instead of the ring that comes from a sound spot; if the detached portion be encircled with a cut made with a chisel, dividing the coat through, it comes away from the shell showing, in the case of a zinc attached shell, a yellowish green corroded surface beneath.

¹ Capt. F. B. Seymour, R.N., gave the following evidence on this subject to a special committee of the House of Commons on Ordnance, 1862-3. See No. 2300.

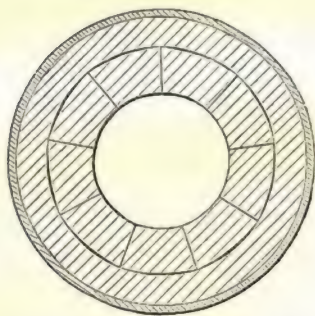
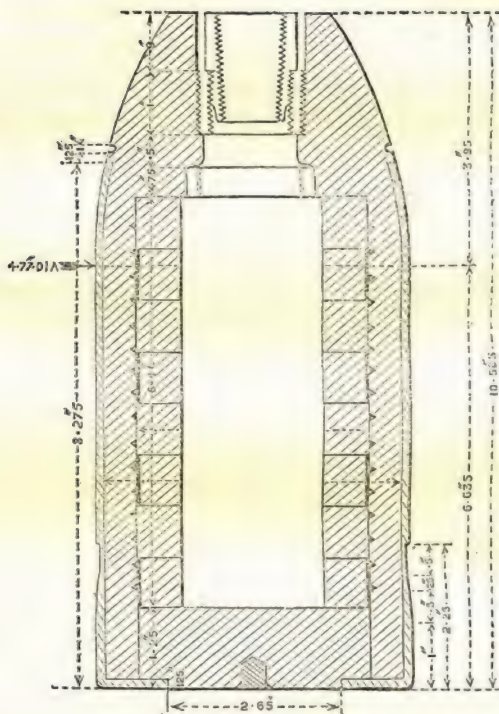
On the 6th of March 1862 "out of 14 rounds three shots stripped in such a way as to look more like canister falling on the water than anything I ever saw before." In March 1861, while the force under General Pratt was attacking the Te Are Pa, "near the Waitara River, in New Zealand, I was in the advanced sap, when a fire was opened over our heads from an Armstrong gun mounted in a redoubt about 600 yards to our rear; on that occasion also some of the shots stripped, the metal from which fell about the sap in a manner which might have endangered the men at work in the sap and in the trenches."

² Mr. Abel, chemist to the War Department, has written a paper on this with the title "A curious instance of Electrolytic Action."

I gather the following from this paper and from information given me by his assistants, Mr. Brown and Mr. Dent, with reference to the chemical changes occurring on the performance of successive manufacturing operations:—

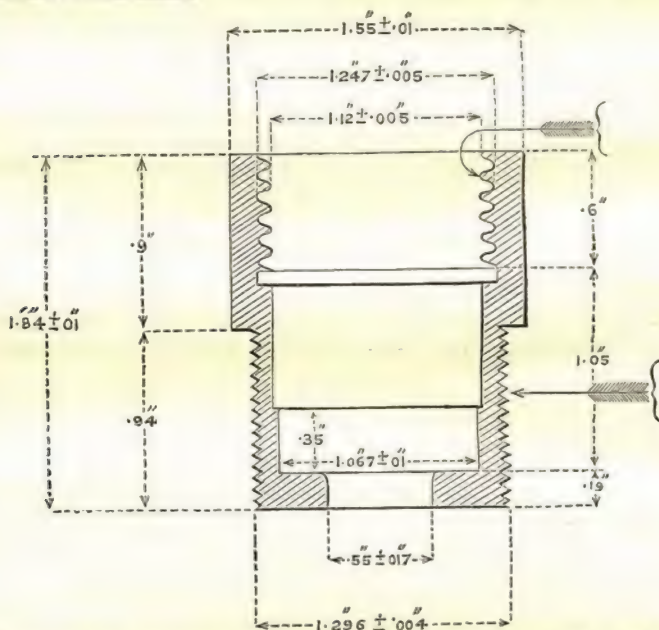
In order to get a clean metallic surface for the zinc to adhere to the shell is dipped in sal-ammoniac solution, by which means any oxides of iron become converted into chlorides (say according to the following equation:— $\text{FeO} + \text{NH}_4\text{Cl} = \text{FeCl} + \text{NH}_3 + \text{H}_2\text{O}$), such chloride of iron is probably left in the bath into which the shell is dipped; but any sal-ammoniac adhering to the shell may cause a similar formation of chloride of zinc, in the next operation, which consists in dipping the shell into molten zinc; this chloride has the property of retaining water at a very high temperature, hence a medium is provided for the commencement of voltaic action between the different metals present (suppose the chemical change so brought about to be illustrated by the following equation:— $\text{Zn} + \text{ZnCl} + \text{HO} = \text{ZnO} + \text{ZnCl} + \text{H}$); the hydrogen so given off forms the blister, and this blister increases gradually if an escape be not provided for the gas.

Mr. Abel has in his possession two shells with curiously large blisters; one blister would nearly cover two half crowns at the present time (September 1870).



ARMSTRONG 40-PR. SEGMENT SHELL.

The 20-pr. common shell stands in an intermediate position between 20-pr. common. the larger and smaller calibres. The O. P. shell, mark I. inclusive, had the Moorsom gauge. To enable the shell when associated with larger calibres to take the same fuzes it has the G. S. adapter inserted; this is done for sea service, while to assimilate it with field batteries and with its own segment shell, as concerning its fuzes, it has a store special to itself, termed a flanged adapter. This might be used as a temporary adapter;¹ it resembles the flanged socket in its interior, and takes the E or F time fuze with C percussion beneath it, or of course, if required, the C screw percussion alone; this is for land service, but hardly any issues have been made.



However, two patterns of this shell have been sealed, one for each service as noticed above.

This, with the 7" common below, are the only instances of a rifled projectile having one pattern for land and another for sea service.

The general rules as to marks on the shells and lead coats given for segment shells (on page 13) apply to common shells also.

It is often very difficult to distinguish common from segment shells; the leading feature is the difference of length.² Any 7" 70, 64, 40, or 20 pr. common shell made at Elswick for the service up to this date may be recognized by having a plugged bottom, the bottom being curved or rounded, and the plug in the centre being flat.

7-inch Common Shell.

The first recorded pattern existing in Royal Laboratory is one approved 21/2/61.³ Length, 18.73 inches; weight, 94 lbs. 14 oz.; it has a conoidal head with nozzle and Moorsom gauge bush, projecting bottom

Shell, rifled,
B.L. common,
7-inch.

¹ Vide Changes of War Stores, § 1345, in which it is called "socket metal," and ordered to be permanently fixed in shells.

² The old 70-pr. (so called) segment shell is the same length as the 64-pr. common shell, viz. about 13.9 inches, but the former has a nozzle.

³ Vide Changes in War Stores, § 211.

with flat centre plug, black lacquer, tin attachment; marks on head E OC and F.

2nd. Approved 30/12/61;¹ pattern in Royal Laboratory; length, 18.75 inches; actual weight of pattern, 97 lbs. 4 oz.; standard weight, 98 lbs. 9½ oz. Conoidal head with nozzle and Moorsom gauge bush, projecting bottom with flat centre plug, black lacquer, undercut attachment; marks on head E OC and F.

3rd. Approved 10/5/62;² pattern in Royal Laboratory, known as the heavy shell I., issued for L.S.; length, 18.7 inches; weight of pattern, 98 lbs. 2 oz.; bursting charge, 7 lbs. 10 oz. Conoidal head with nozzle and Moorsom gauge bush, solid round bottom with flat .25" rim, black lacquer, zinc attachment; marks on coat, Z and date, on base, R L.

4th. Approved 26/3/63³ (no pattern extant), prepared at Elswick; standard weight, 98 ± 2 lbs.; zinc attachment; bursting charge,⁴ 7 lbs. 10 oz.

5th. Approved for naval service 21/3/63⁵ (no pattern extant). Weight, 83½ lbs., to take 6½ lbs.⁶ bursting charge.

6th. Approved 15/9/65;⁷ length, 15.85 inches; standard weight, 83 lbs. ± 1½ lbs. Conoidal head, Moorsom gauge, flat solid bottom, black lacquer, zinc attachment. Marks on coat R $\begin{smallmatrix} L \\ \nearrow \\ A \end{smallmatrix}$, date, and I., and on base $\begin{smallmatrix} Z \\ \nearrow \\ RL \end{smallmatrix}$.

7th. Approved 11/5/67;⁸ length, 15.85 inches; standard weight, 83 lbs.; bursting charge, 6½ lbs. Conoidal head, general service gauge bush, flat bottom, red lacquer, zinc attachment. Marks on coat, R $\begin{smallmatrix} L \\ \nearrow \\ A \end{smallmatrix}$, date, and II.; on base, R $\begin{smallmatrix} L \\ \nearrow \\ D \end{smallmatrix}$.

Of the above the heavy shells of about 98 lbs. weight are issued exclusively for L.S., and the light shells of about 83 lbs. weight for S.S.⁹ or L.S.

N.B.—Patterns with Moorsom gauge may be found with G.S. adapter fixed in them.

A few 7-inch common shell made in the Royal Gun Factories with tin attachment were re-loaded in the Royal Laboratory; such shells are marked on the coats R G F and R $\begin{smallmatrix} L \\ \nearrow \\ Z \end{smallmatrix}$.

Shell, rifled,
B.L. common,
64-pr.

64-pr. Common Shell.

Under this head must be enumerated—

1st. 70-pr. shell, so called. Approved 6/12/62;¹⁰ pattern now in Royal Laboratory; length, 14.7 inches; weight, 63 lbs. 8 oz. Conoidal head with Moorsom gauge bush, projecting bottom with flat plug in centre, black lacquer, zinc attachment. Marks on head, $\begin{smallmatrix} E \\ \nearrow \\ Z \end{smallmatrix}$ OC and C.

¹ Vide Changes in War Stores, 405.

² " " " 541.

³ " " " 753.

⁴ " " " 1116.

⁵ " " " 1038.

⁶ Given as 6½ in Changes in War Stores, § 1038, but corrected to 6½, § 1116.

⁷ Vide Changes in War Stores, 1119.

⁸ " " " 1421.

⁹ The light shell was introduced for S. S. to remedy excessive recoil and fracture of vent pieces, vide Ordnance Select Committee extracts, vol. II., pages 17 and 28, 29, a 11-lb. charge being used with it; for L. S. the heavier and more powerful shell (which corresponds in weight with the segment) is preferred.

¹⁰ Vide Changes in War Stores, § 664.

2nd. 64-pr., so called. Approved provisionally 3/12/64,¹ afterwards permanently; pattern in Royal Laboratory; length, about 13·8 inches; weight, 59 lbs. 8 oz.; capacity for bursting charge, 4 lbs. 8 oz. Conoidal head, Moorsom gauge bush, solid bottom, slightly rounded,

black lacquer, zinc attachment. Marks on coat, $\begin{array}{c} \text{L} \\ \text{R} \uparrow \text{L} \\ \text{A} \end{array}$, date and I,
on base $\begin{array}{c} \text{Z} \\ \text{R L} \end{array}$.

3rd. 64-pr. Approved 26/4/67;² pattern in Royal Laboratory; length, 13·75 inches; standard weight, 60 lbs;³ capacity for bursting charge, 4 lbs. 8 oz. Conoidal head with general service bush, solid bottom, slightly rounded, red lacquer, zinc attachment. Marks on

coat, $\begin{array}{c} \text{L} \\ \text{R} \uparrow \text{L} \\ \text{A} \end{array}$ date and II., on base $\begin{array}{c} \text{Z} \\ \text{R L} \end{array}$.

N.B.—Moorsom gauge shells may be found with G.S. adapters in them.

40-pr. Common Shell.

Shell, rifled,
B.L. common,
40-pr.

The following patterns exist in the Royal Laboratory :—

1st. Approved 22/1/61;⁴ length, 13·87 inches; weight, 38 lbs. 2 oz. Conoidal head with nozzle and Moorsom gauge bush, projecting bottom with flat plug in centre, black lacquer, tin attachment. Marks on head, E OC and C.

2nd. Approved 30/12/61;⁵ length, 13·87 inches; weight, 38 lbs. 10 oz. Conoidal head with nozzle and Moorsom gauge bush, projecting bottom with flat plug in centre, black lacquer, undercut attachment. Marks on head, E OC and C.

3rd. Approved 10/5/62;⁶ length, 13·52 inches; standard weight, 37 lbs. 14 oz. Conoidal head with nozzle and Moorsom gauge bush, flat solid bottom, black lacquer, zinc attachment. Marks on coat Z, date, and I.; on base, RL.

4th. Approved 11/5/67;⁷ length, 13·52 inches; standard weight, 37 lbs. 14 oz.;⁸ capacity for bursting charge, 2 lbs. 4 oz. Conoidal head with nozzle and G.S. bush, flat solid bottom, red lacquer, zinc

attachment. Marks on coat, $\begin{array}{c} \text{L} \\ \text{R} \uparrow \text{L} \\ \text{A} \end{array}$, date and II.; on base $\begin{array}{c} \text{Z} \\ \text{R L} \end{array}$.

N.B.—Moorsom gauge shells may be found with G.S. adapters in them.

Some 40-pr. shell may be met with which were made at Elswick with undercut attachment, and afterwards re-loaded in the Royal Laboratory,⁹ the coat being attached by zinc to the undercut surface; such shells are marked $\begin{array}{c} \text{E OC} \\ \text{R P} \end{array}$ and $\begin{array}{c} \text{R L} \\ \text{Z} \end{array}$.

¹ Vide Changes in War Stores, §§ 1042 and 1116.

² " " §§ 1423 and 1116.

³ Vide sealed pattern drawing.

⁴ Vide Changes in War Stores, § 209.

⁵ " " § 405.

⁶ " " § 541.

⁷ " " § 1425.

⁸ Vide sealed pattern drawing; also Changes in War Stores, § 1116.

⁹ Also a few in the Royal Gun Factory.

Shell, rifled,
B.L. common,
20-pr.

20-pr. Common Shell.

Under this head must be enumerated a 25-pr., so called, with B.L. field service gauge fuze hole, now hardly to be met with.¹ It is declared obsolete, and ordered to be returned to Woolwich to be broken up by Changes in War Stores, § 1815.

The patterns extant in the Royal Laboratory are as follows:—

1st. Approved 4/1/62;¹ length, 11·28 inches; weight, 20 lbs. 5 oz. Conoidal head with nozzle and Moorsom gauge bush, projecting bottom with flat plug, black lacquer, undercut attachment. Marks on head, E OC.

2nd. Approved 4/1/62;¹ length, 10·9 inches; standard weight, 20 lbs. 9 oz. Conoidal head with nozzle and Moorsom gauge bush, flat solid bottom, black lacquer, zinc attachment. Marks on coat, Z, date, and I.; on base, R. L.

3rd. Approved for L.S. only 26/10/66;² length, 10·8 inches; actual and standard weight, 20 lbs. 8 oz. Conoidal head with flanged socket, solid flat bottom, red lacquer, zinc attachment. Marks on coat,

$\begin{array}{c} \text{L} \\ \text{R} \nearrow \text{L} \\ \text{A} \end{array}$, date, and II.; on base $\begin{array}{c} \text{Z} \\ \text{R} \text{L} \end{array}$.

4th. Approved for S.S. only 26/4/67;³ length, 10·88 inches; standard weight, 20 lbs. 8 oz.; capacity for bursting charge, 1 lb. 2 oz. Conoidal head with nozzle and G.S. bush, flat solid bottom, red lacquer,

zinc attachment. Marks on coat $\begin{array}{c} \text{L} \\ \text{R} \nearrow \text{L} \\ \text{A} \end{array}$, date, and III.; on base $\begin{array}{c} \text{Z} \\ \text{R} \text{L} \end{array}$.

Shells with the Moorsom gauge, by means of the flanged adapter or G.S. adapter, may be brought to correspond with the G.S. or S.S. pattern respectively, as noticed on page 26.

The bronze edge of the flanged socket seen beneath the plug of II. is a very distinct mark of identification.

Shell, rifled,
B.L. common,
12-pr.

12-pr. Common Shell.

The following sealed patterns exist in the Royal Laboratory:—

1st. Approved 3/1/65;⁴ length, 8·5 inches; standard and actual weight, 10 lbs. 8 oz.; capacity for bursting charge, 9½ oz. Conoidal head, B.L. field service fuze hole, solid flat bottom with edge slightly rounded. About 1·9 inches length of surface of lead coat removed from the front part to enable the shell to enter the grip of the bore. Black

lacquer, zinc attachment. Marks on coat, $\begin{array}{c} \text{L} \\ \text{R} \nearrow \text{L} \\ \text{A} \end{array}$, date, and I.; on base $\begin{array}{c} \text{Z} \\ \text{L} \text{R} \end{array}$.

12-pr., II.

2nd. Approved 26/10/66;⁵ length, 8·35 inches; standard weight, 10 lbs. 8 oz.; capacity for bursting charge, 9½ oz. Conoidal head with flanged socket, flat bottom with rounded edge, lead removed as above,

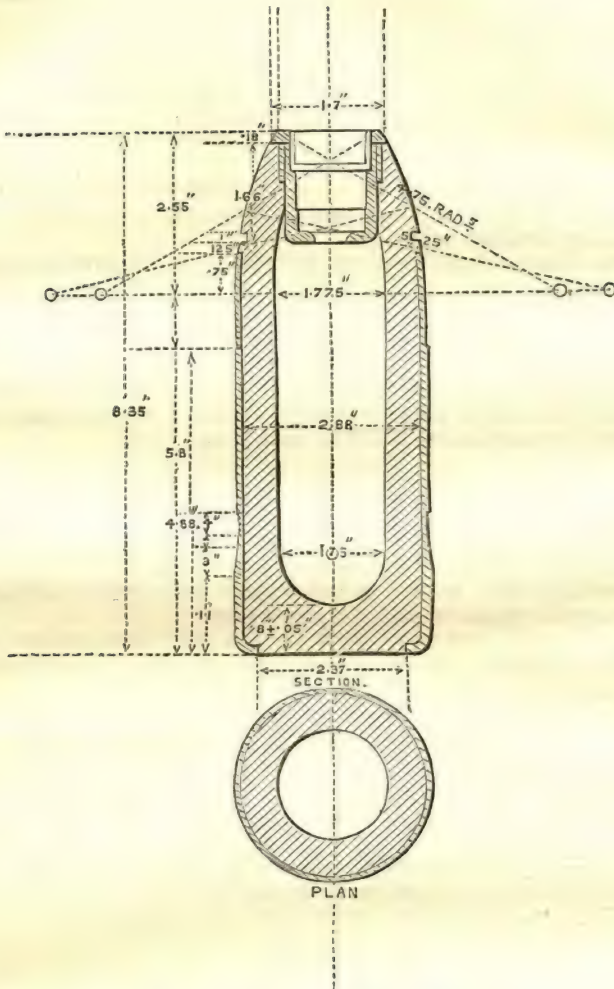
red lacquer, zinc attachment. Marks on coat $\begin{array}{c} \text{L} \\ \text{R} \nearrow \text{L} \\ \text{A} \end{array}$, date, and II.; on base $\begin{array}{c} \text{Z} \\ \text{R} \text{L} \end{array}$.

¹ Two of these shells were returned by H.M.S. "Niger" in the winter of 1868.

² Vide Changes in War Stores, § 477. ³ Vide Changes in War Stores, § 1087.

³ " " " 1342. ⁶ " " " § 1343.

⁴ " " " 1426.



12-PR. B.L. COMMON SHELL II.

The bronze edge of the flanged socket seen beneath the plug is a very obvious mark of identification, especially when standing in a limber box or ammunition wagon.

9-pr. Common Shell.

Shell, rifled,
B.L. common,
9-pr.
9-pr., I.


The following sealed patterns exist in the Royal Laboratory :—

1st. Approved provisionally 9/12/65; length, 6.45 inches; standard weight, 8 lbs. 2½ oz. Conoidal head with B.L. field service fuze hole, flat bottom with rounded edge, red lacquer, zinc attachment. Marks on

coat, $\begin{pmatrix} L \\ R \nearrow L \\ A \end{pmatrix}$, date, and I.; on base $\begin{pmatrix} R L \\ Z \end{pmatrix}$.

9-pr., II.

2nd. Approved 9/11/66;¹ length, 6·5 inches; weight of pattern, 8 lbs. 2½ oz.; capacity for bursting charge, 6½ oz. Conoidal head with flanged socket, flat bottom with rounded edge, red lacquer, zinc attachment. Marks

on coat,  , date, and II, ; on base $\begin{matrix} Z \\ R L \end{matrix}$.

The bronze edge of the flanged adapter seen beneath the screw plug is a very ready mark of identification, especially when standing in a limber or ammunition wagon.

Paint.—The head and base are painted black (as given for segment shell, page 16).

Issue of common shells.

1st. Filled.

ISSUE OF COMMON SHELLS.

1st. Filled.

7" 40 and 20 pr. common shells have been issued for sea service, filled and fuze with pillar percussion fuzes,² any so issued since 27/10/66 being marked "Filled" in red letters.⁴

All these shells issued since 5/8/67 would either have the G.S. adapter fixed in the shell or would have the G.S. fuze hole, the G.S. percussion fuze being used instead of the pillar.

By departmental order, 24/3/70, all shells filled in Royal Laboratory are now marked R/Λ L W and date of issue in red.⁵

N.B.—Shells with unloading holes would have papier-mâché wads in the unloading holes beneath the screw plug.⁶

12-pr., Mark II., and 9-pr.⁷ Mark II.⁷ (i.e. only those patterns which have flanged sockets) are issued filled, the holes in the bottoms of the sockets being closed by papier-mâché wads, the fuze holes being closed by the usual screw plug with loop.

When issued from the Royal Laboratory such shells would be marked "Filled" in red letters, but when filled by the batteries themselves⁸ it is improbable that they would be so marked, and it should be borne in mind that all shells carried in limbers are now filled⁹ although not generally so marked.

Mark I.—12-pr. and 9-pr. are not to be carried filled, the powder being liable to escape in the event of the screw plug working out (no more will be issued).

2nd. Empty.

2nd. Empty.

7" 64, 40, and 20 prs. for L.S. and 7" 40 and 20 prs. for S.S. were formerly issued empty with Moorsom gauge screw plugs.

Since 5/8/67 such shells (with the exception of a few 20-prs. issued with flanged adapters) would have either G.S. adapters fixed in them, or G.S. fuze holes with G.S. screw plugs, and such as were issued for

¹ *Vide* Changes in War Stores, § 1344; date, 9/11/66.

² *Vide* quotation of Changes in War Stores, § 1089 given on p. 16.

³ *Vide* note on segment shells with pillar fuzes, p. 16, note ⁵.

⁴ *Vide* notes on segment shell issued for S.S., p. 17, note ².

⁵ See also Changes in War Stores, § 1880, and note, p. 17, note ².

⁶ Approved 1/5/69. *Vide* Changes in War Stores, § 1764.

⁷ A few 12 and 9 prs. with flanged sockets were at first issued filled, with the wood serge covered plugs used in segment shells, in their flanged sockets, but there is no certainty that these plugs might not come out in cases where the screw plugs worked out. It will be seen that shells carried filled in field batteries are intended to be secure against escape of powder and consequent danger apart from any limber fittings keeping their plugs home, such fittings being liable to be broken or not to be closed down on service.

⁸ No 12 and 9 pr. common shells have been issued for S.S.

⁹ *Vide* Changes in War Stores, § 1581.

S.S.¹ since 30/11/66 have blue waxed wads in the fuze hole recesses over the screw plugs to distinguish them the more readily from filled shells.

N.B.—On 28/2/66 kit plasters were approved of to cover fuze holes, but never used.

Mark I. 20, and I. and II. 12, also I. and II. 9-prs., have been issued empty with screw plugs with string loops.

Mark II. 20-prs. have never been manufactured.

Shells are placed in jute bags when sent to India.

USE AND EXPERIENCE WITH B.L. COMMON SHELL.

Common shell would be generally fired with percussion fuzes or time fuzes to act on impact against matériel.²

There is very little to observe as to their performances. The main feature to notice is the relation borne by their bursting charges to those of the shells of the smooth-bore guns, which may be said to correspond with them.³

B.L. Guns.

S.B. Guns.

7-inch heavy shell	7 lbs. 10 ozs.	{	10-inch	-	-	6 lbs. 5 ozs.
„ light do.	- 6 „ 8 „	{	100-pr.	-	-	3 „ 13 „
64-pr. -	- 4 „ 8 „	{	68-pr. or 8-inch	2	„	9 „
40-pr. -	- 2 „ 4 „	{	32-pr.	-	-	1 „ 5 „
20-pr. -	- 1 „ 2 „	{	24-pr.	-	-	1 „ 0 „
12-pr. -	- 0 „ 9½ „	{	18-pr.	-	-	0 „ 12 „
9-pr. -	- 0 „ 6½ „	{	12-pr.	-	-	0 „ 7 „

The fact of the rifled shells holding more powder than might be expected is due to their being elongated to bring them up to the same weight as other projectiles, for instance, the 64-pr. weighs 60 lbs. empty and 64 lbs. 8 oz. filled, while the 8-inch shell for 68-pr. gun only weighs 48 lbs. empty and 50 lbs. 9 oz. filled. Hence 64-pr. guns weighing 64 cwt. would have a much more powerful shell than the 68-pr. weighing 95 cwt.⁴

With common rifled shells having pillar fuzes in them occurred the accident at Malta in 1867; it is probable that this arose from using force to extract one of these fuzes (*vide* p. 16, note ⁵).⁵

Premature explosion sometimes occurs from flanged sockets giving way.

BOXER SHRAPNEL.

Calibres 7", 64, 40, 12, and 9 pr. Each shell consists of a hollow body with a head lightly attached to it. The body is of cast iron; it has a lead and antimony coat to take the grooving, in the case of the 40-pr. resembling exactly that of the segment shell Mark I., and in the case of the 7-inch and 64-pr. differing only in having the thick part of the coat which gives the larger diameter, moved 2.5" forward from the base in order to cause the shell in ramming home to lodge 2.5" short

¹ *Vide* Changes in War Stores, § 1190, date of approval of the kit plaster being so used being 28/2/66.

² The time fuze if set too long may be frequently driven in so as to fire the shell on impact.

³ *Vide* Changes in War Stores, § 1116.

⁴ The way one of the Lancaster shell with its large bursting charge told on the top tier of the Malakoff tower is given, p. 7.

As to questions of stripping see segment shells, p. 24. For lacquer, page 12, note ³.

⁵ 7" and 64-pr. B.L. shells will be made with unloading holes for the future, *vide* Changes in War Stores, § 1764.

of its intended seat, and so to bring it closer to the charge of powder which does not fill up the entire powder chamber; this arrangement makes the shell start more suddenly, and causes its fuze to ignite with greater certainty. Externally the 12 and 9 pr. shrapnel *bodies* nearly correspond with their respective segment and common shells.

The body is weakened internally by six longitudinal grooves running down the entire length of the interior, and forming lines of least resistance. The base is formed into a chamber to contain the bursting charge, the interior of the body is slightly conical, that is, it enlarges slightly towards the front, giving an increase of .1" in diameter in larger, and .05" in smaller calibres at the mouth; running round the mouth is a shoulder and groove forming a kind of recessed lip.

Over the mouth of the powder chamber rests a disc of iron or "diaphragm"¹ supported either by flanges or by a shoulder, according to the pattern; the diaphragm is pierced in the centre and partly tapped to take a wrought-iron "tube" which is screwed into it, this tube itself being tapped at the top to take a gun-metal primer employed to assist in carrying the flash of the fuze to the bursting charge in the chamber.

On the diaphragm are placed bullets² of lead and antimony, which are fixed by rosin being run in among them, brown paper being laid round the inside of the shell to prevent too firm adhesion of the rosin. Over the bullets and rosin is placed a kamptulicon disc.

The head is made of elm covered with a light shell, formerly of wrought iron, latterly of Bessemer metal, the wood being bored out to contain a tin socket fitting round the iron tube of the body and holding in its mouth a gun-metal bush of G.S. gauge tapped to take the G.S. screw plug; this bush forms a small projecting socket above the apex of the shell.

It will be seen that the chief functions of the head are to cut through the air in flight and contain the fuze; being very light it brings the centre of gravity of shell, which would otherwise come too far forward, to its proper position, and its inertia being reduced it is possible to hold it to the shell by a light method of attachment, viz., by means of steel rivets (12 in larger and 4 in smaller shells) and four steel twisting pins, these latter being rivets sometimes fitted into slots instead of holes in the shell, so as to tend to prevent the head by its own inertia twisting away from the body, although in no way interfering with its liberation when blown to the front by the bursting charge.

The 64-pr. has its tube surrounded by a hollow elm wood cylinder to enable its proportions to be good consistently with the calibre and weight required. All have weighed bursting charges of "service pistol powder."

The 7" 64 and 40 pr. shells takes the 9 secs.,³ the 12 and 9 the 5 secs. B.L.R.O. fuze.

DISTINCTIVE MARKS.

Shrapnel are readily distinguished from common shell and segment by the projecting socket, and also by the head being fitted with a shoulder or lip at the front of the body; this latter mark is less distinct in the 40, 12, and 9 pr. shrapnel than in the 7-inch and 64-pr.

¹ Called after the plate separating powder and bullets in the smooth-bore diaphragm shell.

² In the 7" and 64-pr., 14 to the lb., in the 40-pr. 16 to the lb., in the 12 and 9 pr. both 18 and 34 to the lb.

³ The 20 secs. does not fit the socket; besides having no powder channels it seems very doubtful whether it would ignite the primer.

The details of each pattern are as follows :—

7-inch Shrapnel.

Shell, rifled,
B.L. Shrapnel,
Boxer, 7-inch.

1st. Approved provisionally 28/1/67.¹ Pattern in Royal Laboratory. Length, 16·1" (measuring to end of bush); standard weight, 96 lbs.; ²bursting charge, 8 oz.; contains 360 mixed metal bullets 14 to the lb. a cast-iron diaphragm with gutta-percha disc beneath it, supported on three flanges in the powder chamber, which is lined with marine

glue. External marks are, on coat I. $\begin{array}{c} \text{L} \\ \text{R} \nearrow \text{L} \\ \text{A} \end{array}$ and date, on base

R L

Z .

2nd. Approved 4/4/68.³ Pattern in Royal Laboratory. Length, 16·1 inches; standard weight, 97 lbs.; ⁴bursting charge, 8 oz.; containing a wrought-iron diaphragm, resting on a shoulder formed by the edge of the powder chamber, which is smaller than that for the bullets, and is lined with a tinned iron cup closed over except a small central pipe fitting to the tube; this arrangement being adopted to prevent premature explosion, which occurred with some shells of the previous pattern, either from powder in some way working in between the diaphragm and shell, or from the cast-iron diaphragm chipping and breaking into the powder, for it requires great care to fit the diaphragm so as to receive even support from the three flanges; besides the metal was too brittle; it contains 305 mixed metal bullets 14 to the lb. The

external marks are, on coat II. $\begin{array}{c} \text{L} \\ \text{R} \nearrow \text{L} \\ \text{A} \end{array}$ and date, on base $\begin{array}{c} \text{R L} \\ \text{Z} \end{array}$.

64-pr. Shrapnel.

Shell, rifled,
B.L. Shrapnel,
Boxer, 64-pr.

1st. Approved 28/1/67.⁵ Pattern in Royal Laboratory. Length, 13·6"; standard weight, 66 lbs.; ⁴bursting charge, 5 oz.; contains a cast-iron diaphragm with gutta-percha disc beneath, supported on three flanges in the powder chamber, which is coated with marine glue; it contains 224 mixed metal bullets 14 to the lb. External marks, I.

$\begin{array}{c} \text{L} \\ \text{R} \nearrow \text{L} \\ \text{A} \end{array}$ date, on base $\begin{array}{c} \text{R L} \\ \text{Z} \end{array}$.

2nd. Approved 4/4/68.³ Pattern in Royal Laboratory. Length, 13·47"; standard weight, 65 lbs. 14 oz.; ⁴bursting charge, 5 oz.; contains a wrought-iron diaphragm and chamber lined with tin (*vide* 7", Mark II.), to prevent premature explosion. Marks on coat,

II. $\begin{array}{c} \text{L} \\ \text{R} \nearrow \text{L} \\ \text{A} \end{array}$ and date, on bottom, $\begin{array}{c} \text{Z} \\ \text{R L} \end{array}$.

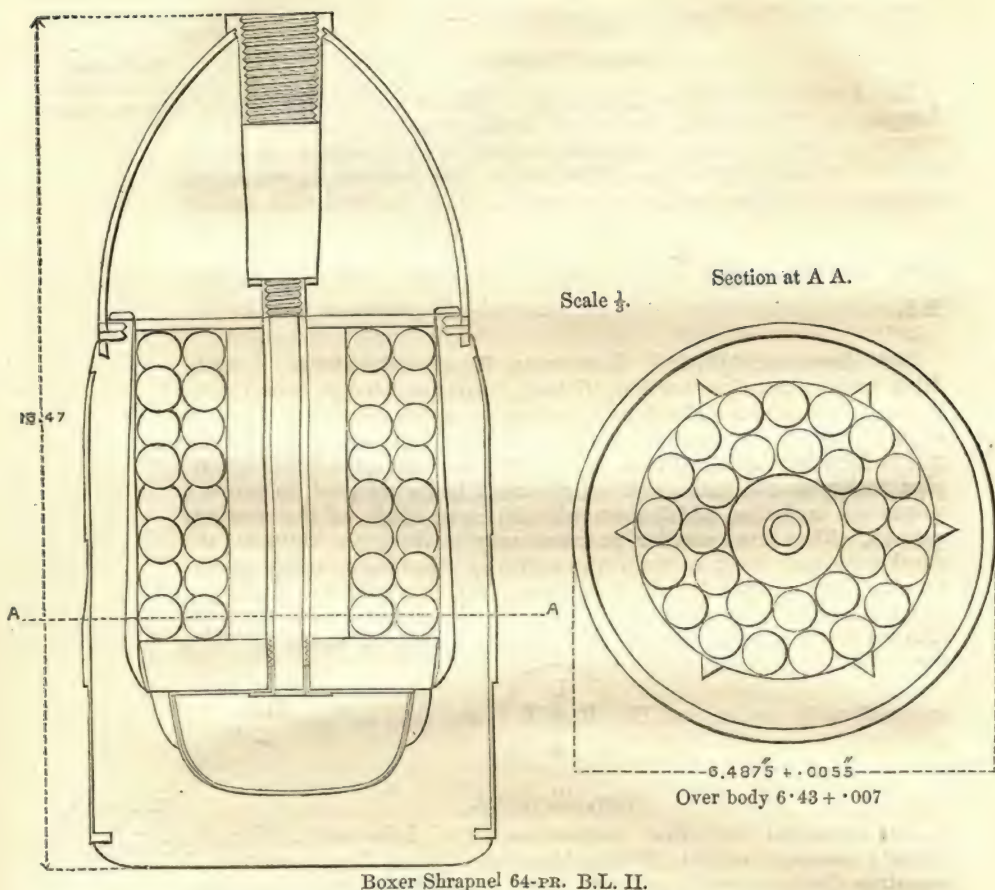
¹ *Vide* Changes in War Stores, § 1422.

² This is to be given by weight.

³ *Vide* Changes in War Stores, § 1609.

⁴ To be given by weight.

⁵ *Vide* Changes in War Stores, § 1391.



Boxer Shrapnel 64-pr. B.L. II.

Shell, rifled,
B.L. Shrapnel,
Boxer, 40-pr.

40-pr. Shrapnel.

Approved 7/7/69.¹ Pattern in Royal Laboratory. Length, 12.38"; standard weight, 39 lbs.; ² bursting charge, 3 oz.; contains 162 mixed metal bullets 16 to the lb.; it has a wrought-iron diaphragm and chamber

lined with tin (*vide* 7", Mark II.) Marks on coat, I. L
R ↑ L
A and

date, on base R L
Z.

The 12 and 9 pr. shrapnel, Mark I., submitted for scaling, are as follows:—

Both have wrought-iron diaphragms and chambers lined with tin.

12-pr. Length, 8.415"; standard weight, 10 lbs. 11 oz.; bursting charge, 12 drs.; contains 42 bullets 18 to the lb., and 14 of 34 to the lb.

9-pr. Length, 7.15"; standard weight, 18 lb. 10 oz.; bursting charge, 12 drs.; contains, 21 bullets 18 to the lb., and 21 of 34 to the lb.

¹ *Vide* Changes in War Stores, § 1807.

² To be given by weight.

Paint.—The heads and bases of 7", 64, and 40 prs. are painted black Paint. (as given for segment shell, *vide* page 16); the heads of 12 and 9 prs. are painted red and the bases black.

ISSUE OF SHRAPNEL.

Issue.

1st. Filled.

7" and 40-pr. would be issued filled for S.S., with primers inserted and screw plugs, 40-pr. also to batteries of position¹, and 12 and 9 prs. to field batteries, marked "filled" with date R \wedge L and W in red paint on the black heads, and black on the red.

2nd. Empty.

7", 64, and 40 pr. issued empty for L.S., with screw plugs.

Any of the above might be placed in boxes for transit, or jute bags for India.

Use.

Use of Shrapnel.

The effect of shrapnel like that of segment greatly depends on the correct estimate of the results that are being produced, and in most cases on the judgment displayed in the constant efforts to improve on the shooting when used intelligently, the effect is most excellent.

It is possible generally from the gun to estimate the line and the height of the burst of the shell, but not the distance at which it occurs, and bad practice commonly arises from a too sanguine estimate of effects judging from the appearance of the smoke of the burst alone; particular attention should therefore be paid to any visible marks of the bullets grazing. On water, splashes will be seen; on dry ground, puffs of dust; on ice, very distinctly scored marks; on wet or boggy ground nothing is commonly visible.

Shrapnel should be burst closer to compact masses of troops than to more open formations.

Experience.

B.L. shrapnel have not been tried on active² service. As to practice

¹ *Vide* Changes in War Stores, § 1581 & 1880.

² Experience as to the effect generally of rifled shrapnel might have been gleaned, it may be supposed, from continental or American wars, but England in the matter of shrapnel appears to have always been in advance of other nations, and has reaped the benefit of it. Many may doubt this, however, and it may be well to note the following:—

I have heard from Russian officers of high rank who have visited Woolwich Arsenal, that percussion fuzes are exclusively used throughout the Russian service. One officer jeered at the idea of boring a time fuze in action.

The Prussians used percussion fuzes only in their war with Austria, but they have now time fuzes also, it is said the segment shell is ranked very high indeed by some of them, though it does not appear to have been adopted.

The Austrians used time fuzes with their shrapnel.

The French have a shrapnel and percussion fuze, also some very rough time fuzes.

The Danes have tried the segment shell, but the Danish officer who was my informant abused it in unmeasured terms.

With regard to Russia, I would remark that possibly some English officers are better judges as to the accuracy with which Russian soldiers used to set their fuzes than the General in question; at all events, any failure in this respect would be more likely to be due to want of instruction than to want of nerve; and, indeed, a sneer which implied the inefficiency and habitual want of presence of mind of nearly the whole detachment at the gun will not carry weight with those who have seen active service, and is certainly not deserved by Russian troops.

As to Prussia, with its percussion fuze, Captain Brackenbury, who was with the Austrian army in their last war, in his "European Armaments" writes:—"The Prussians made a great mistake during the late war in using percussion fuzes with their shrapnel shell. These may be all very well on level ground and at a short range, when the shell can ricochet, but what usually happened was that the Prussian shrapnel struck some projection in the earth or the face of a hill, and gave a feeble exclamation from the grave it dug for itself, no harm resulting to the enemy; very frequently it did not burst at all. The Austrian shrapnel was successful at ranges

at home, much has already been referred to in the comparison between segment and shrapnel,¹ *vide* pages 17 to 23.

Boxer shrapnel have superseded segment to a great extent for large calibres, and are recommended to come in for smaller calibres in a certain proportion.

Classes.

B.—SHOT.

Are of the following classes:—

1st. Solid shot.

2nd. Drill „

3rd. Case „

Solid shot.
Calibres.

SOLID SHOT, CALIBRES 40, 20, 12, 9, AND 6 PRS.

In their general external form, solid shot much resembles segment shell, but they differ slightly in length. In the 40-pr., the solid shot being rather shorter, and in other calibres rather longer than the segment shell.

The weight of the shot generally exceeds that of the segment shell of the same calibre, the coats of both projectiles have been attached by the same methods.

Economy appears to have been the chief recommendation of these projectiles, which were first introduced for practice with the 12-pr.,

“ up to 2,000 yards, but did not crown the hopes of those artillerymen who would like “ to bombard the enemy at a distance of half a day’s march.”

The Americans made some very crude experiments with a projectile never regularly tried by us, though proposed by General Boxer some years since, viz., vertical shrapnel. It appears very desirable that the powers of such a projectile should be thoroughly tested. Many officers know what is the moral effect of vertical case; on it the school of Coehorn depended mainly for defence, but the penetration is small; at short ranges it scatters too much, and cannot safely be fired over the heads of troops.

The whole of these difficulties are met by vertical shrapnel, which can be used at long ranges, need not scatter, but might be opened near the spot desired, and could be fired over the heads of troops, while at short ranges by firing it at very high angles considerable velocity might be attained. The effects of vertical fire of shell are well known to any officer who has been under it. It is commonly used without sufficient care and judgment to have even its fair chance of injuring “ matériel,” and excepting in the case of a bombardment of large masses of buildings, &c., the probability of dropping a shell upon the object aimed at is, even under the most skilful direction, exceedingly small.

As to men, the moral effect is at first considerable, but it can hardly be expected to be lasting, for the number of shells that will fall and burst in a battery without injury to any one is a matter of astonishment to those who first experience the effects of heavy vertical fire. Over and over again may be seen enormous shells exploding harmlessly, within a few feet of men lying or stooping round them, and it requires a little thought to see why a shell bursting on or partly in the earth should have so small a probability of inflicting injury.

I think few officers who have had much experience of the fire of mortar shell would prefer to have shrapnel opening a few feet over their heads, in proof of which I would add that in the siege of Sebastopol shell bursting a little short were considered so much more dangerous than those with long fuzes, that English shells have been purposely burst in this way when firing on bodies of men. On the last night of the siege some mortar shells so prepared were thrown into the crowded gorge of the Redan, and a Russian officer who I ascertained had been there, and whom I afterwards questioned as to the effect, informed me that it was very great, indeed so marked was it, that an English artillery officer heard the matter again mentioned in the Russian camp; yet it hardly seems likely that the effect of these shell could compare with that of vertical shrapnel.

¹ It would be improper to discuss the relative merits of the two projectiles. What appear to be a few leading points, giving the sense of each committee report, will be found in the foot notes.

For M.L. 7-pr. shrapnel on active service, see page 98, text, and note 1.

though afterwards adopted for service with certain calibres. The 40-pr. shot has been issued for both land and sea service until by changes in war stores § 1769, 23rd December 1868, and 12th April 1869, it was directed that 40-pr. B.L. shot should be withdrawn from the proportion of service stores, and segment or shrapnel shell substituted for them; however, by § 1827 in changes issued 1st November 1869, the withdrawal was limited for the present as far as concerns L.S. to garrison equipments.¹

20-pr. solid shot have been issued as service shot both for land and sea service.

12-pr., 9-pr., and 6-pr. have been issued as service shot to the navy, but for practice only, for land service.

Obsolete Shot, Solid and Hollow.—In addition to the above solid shot of various patterns enumerated below have been approved for² 7" and 64-pr.³ guns, beside hollow shot or battering shell⁴ for the former, and hollow-headed shot⁵ for the latter gun; as these might possibly be met with they are given below, the hollow shot being taken in their order of succession after the solid of the same calibre. All 7" and the 70-pr. solid shot are now obsolete; hollow and hollow headed shot to be expended and no more manufactured.¹¹

N.B.—It need hardly be observed that solid shot for practice and service are at once distinguished from segment shell by the absence of fuze holes.

The general rules as to marks on segment shell given on page 13 apply to shot also.

Details of Patterns.

Three service patterns of solid shot for the 7" B. L. gun are deposited in the Royal Laboratory pattern room, besides four patterns of proof shot,⁶ and one hollow shot formerly termed a "battering shell."⁷

All the solid shot are about 12·3 inches long, and their weights vary only between 108 lbs. 8 ozs. and 110 lbs. 10 ozs.; all have short heads of nearly hemispherical form and flat bottoms; the service patterns are as follows:—

1st. 100-pr.⁸ so called, approved about 16/8/61, tin attachment. Marked on base R. L.

2nd. 100-pr.⁹ so called, approved 30/12/61, undercut attachment. Marks on head E O C B.

3rd. 100-pr.¹⁰ so called, approved 2/12/61, zinc attachment. Marks on coat Z, date and I, on base R L Z.

Shot, rifled, B.L. solid (100-pr. not given in priced vocabulary). Details of patterns.

¹ That is, the batteries of position retain them at present.

² For approval of each description, see details of patterns, pp. 39 & 40.

³ Approved Changes in War Stores, § 663, 3/12/62, weight 70 lbs.

⁴ *Vide* Changes in War Stores, §§ 1038 and 1085.

⁵ " " § 1190, for S.S., date 28/11/66 and for L.S., but directing that the existing store of 7" hollow bodied shot be used up. *Vide* § 1347, date 30/10/66.

⁶ For authority for proof shot, *vide* Changes in War Stores, § 477, 4/1/62, also § 599, 30/6/62.

⁷ For condemnation of solid shot, and introduction of hollow shot or battering shell, *vide* Changes in War Stores, § 1038, 20/1/65 and 21/3/65.

For battering shell, also *vide* Changes in War Stores, § 1085, 30/5/65.

⁸ Changes, § 331 gives a shot about this date made at Elswick that I cannot identify with this or any pattern extant.


⁹ *Vide* Changes in War Stores, § 405.

¹⁰ § 405, also note following, § 405.

¹¹ By W.O. Order 4/9/66, 75/12/2917, and 15/9/66.

All these were condemned 20/1/65,¹ and hollow shot substituted 21/3/65. The solid shot² are now ordered to be returned to Woolwich and broken up.

The 7-inch battering shell³ afterwards termed hollow shot, approved 30/5/65, is 12·5 long; weight, 88 lbs.; capacity for bursting charge, 2 lbs. 14 oz.; it has a conoidal head and flat bottom; it has an unbushed fuze hole G.S. gauge, taking G.S. screw plug, or when used as a battering shell Pettman's G.S. percussion fuze; it is lacquered internally with red

lacquer,⁴ it has zinc attachment. Marks on coat , date and I, on base $\begin{matrix} Z \\ R\ L \end{matrix}$.

It is readily known externally by its unbushed fuze hole, it is now obsolete.

64-pr. Shot.

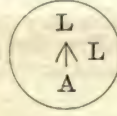
Under this head must be classed the following patterns deposited in the Royal Laboratory, but both obsolete:—

Shot, rifled,
B.L. solid
(64-pr. and
70-pr. not
given in priced
vocabulary).
1st. Solid shot,
70-pr. (so
called).

1st. Solid shot 70-pr. so called, approved provisionally⁵ 3/12/62; length, 11·9; weight, 79 lbs. 4 ozs.; conoidal head, flat bottom, zinc attachment. Marks on head $\begin{matrix} E\ OC \\ Z \end{matrix}$.

2nd. Hollow-
headed shot,
64-pr.

2nd. Hollow-headed shot 64-pr. so called, approved provisionally 3/12/64;⁶ length, 12 inches; weight, 65 lbs. 2 ozs.; conoidal head with a hollow in it plugged up with a wrought-iron plug at apex, flat

bottom, zinc attachment. Marks on coat , date and I, on base $\begin{matrix} Z \\ R\ L \end{matrix}$.

Shot, rifled,
B.L. solid,
40-pr.
Three patterns.

40-pr. Solid Shot.

Of this there are three patterns in the Royal Laboratory, all have conoidal heads and flat bottoms; they are as follows:—

1st. Approved 22/1/61;⁷ length, 10·25 inches; weight, 41 lbs. 4 ozs.; tin attachment. Marks on head E OC and B.

2nd. Approved 30/12/61;⁸ length, 10·15 inches; weight, 41 lbs. 2½ ozs.; undercut attachment. Marks on head E OC and B.

3rd. Approved 2/12/61;⁸ length, 10·27 inches; standard weight, 40 lbs. 13½ ozs.; zinc attachment. Marks on coat Z, date, and I; on base $\begin{matrix} R\ L \\ C \end{matrix}$.

Shot, rifled,
B.L. solid,
20-pr.
Four patterns.

20-pr. Solid Shot.

Of these there are the following patterns in the Royal Laboratory. All are from 8·195 inches to 8·31 inches long and have conoidal heads and flat bottoms; they are as follows:—

¹ Vide Changes in War Stores, § 1038.

² " " § 1815.

³ " " §§ 1038 and 1085.

⁴ It is erroneously stated in Changes in War Stores that it is not lacquered internally.

⁵ Vide Changes in War Stores, § 663.

⁶ " " § 1042.

⁷ " " § 209.

⁸ " " § 405.

1st. Approved provisionally 31/7/61;¹ weight, 20 lbs. 6½ ozs.; tin attachment. Marks on coat, date only; on base R L.

2nd. Approved 30/12/61;² standard weight, 20 lbs. 9½ ozs.; undercut attachment; there are no marks on any part of this shot.

3rd. Approved 2/12/61;² standard weight, 20 lbs. 9¼ ozs.; zinc attachment. Marks on coat Z, date, and I; on base $\begin{matrix} R & L \\ I & \end{matrix}$.

4th. Approved 25/9/66;³ pattern in Royal Laboratory; standard weight,

20 lbs. 9¼ ozs.; zinc attachment. Marks on coat $\begin{matrix} L \\ R \uparrow L \\ A \end{matrix}$, date and

II.; on base $\begin{matrix} R & L \\ I & \end{matrix}$.

This shot has a tarred string loop through the head for lifting it out of limbers, &c.

12-pr. Solid Shot.

Of these there are in the Royal Laboratory, two service patterns, two patterns "for practice," and two "for proof,"⁴ there is an undercut shot approved of which there is no pattern extant.

All are from 6·95 inches to 7·05 inches in length, all have conoidal heads and flat bottoms.

The service and practice shot are as follows :—

1st. "Practice" shot; about 2/11/60; pattern in Royal Laboratory; weight, 11 lbs. 10 ozs.; tin attachment. Marks on head, E OC and A.

2nd. "Practice" shot; approved, 21/11/60;⁵ pattern in Royal Laboratory; weight, 11 lbs. 10 ozs.; tin attachment. Marks on head, E OC and A.

3rd. "Practice" shot; approved, 20/5/61;⁶ pattern in Royal Laboratory; weight, 11 lbs. 9½ ozs.; tin attachment. Marks on head, E OC and C.

4th. Shot; approved 2/12/61;² no pattern extant; weight, 11 lbs. 7 ozs.; undercut attachment.

5th. Approved, 4/1/62;⁴ pattern in Royal Laboratory; standard weight, 11 lbs. 7 ozs.; zinc attachment. Marks on coat, Z, date, and I; on base R L.

9-pr. Solid Shot.

Of these there is only one pattern⁷ approved for practice, 2/8/62; length, 5·6 inches; standard weight, 8 lbs. 13 ozs.; conoidal head, flat bottom; zinc attachment. Marks on coat, Z, date, and I; on base

C
R L.

6-pr. Solid Shot.

Of these there are three patterns in the Royal Laboratory, and one pattern was approved which is not extant, all are from 5·3 inches to 5·35 inches long, and from 6 lbs. 2 ozs. to 6 lbs. 4 ozs. in weight.

Shot, rifled,
B.L. solid,
12-pr.
Two service
patterns.
Two practice
patterns.
Two proof
patterns.
Practice shot.

Shot, rifled,
B.L. solid,
9-pr.
One pattern.

Shot, rifled
B.L. solid,
6-pr.
Three patterns.

1	Vide Changes in War Stores,	341.
2	" "	405.
3	" "	1298.
4	" "	477.
5	" "	162.
6	" "	270.
7	" "	600.

All have conoidal heads and flat bottoms, they are as follows :—

1st. Approved, 3/7/61;¹ made at Elswick; tin attachment. Marks on head, D.

2nd. About 14/8/61; no record of approval; made at Elswick; tin attachment. No marks on head; on coat, 1 \wedge A.

3rd. 2/12/61.² Made at Elswick; undercut attachment; no pattern extant.

4th. 4/1/62.³ Zinc attachment; standard weight, 6 lbs. 2 ozs. Marks on coat Z, date, and I; on base R L.

Paint.—The heads and bases are painted black (as described for segment shell, *vide* p. 16).

Issue of shot.

Issue of Shot.

They are issued loose, but might be packed in boxes if convenient for transit, or jute bags for India.

Experience with solid shot.

Experience with Solid Shot.

The larger calibres strained the guns from their weight, and shot comparatively badly from their length, for it appears that the minimum length for good shooting is two calibres, and the shell has an advantage from having its weight so disposed as to give a longer radius of gyration and therefore a better spin. For larger calibres the penetrative powers of solid shot might probably exceed that of shell, but for smaller calibres a solid shot seems a very useless projectile for service, for the strength of the segment shell is considerable, and its penetration has been found good, (*vide* Major Hay's evidence on experience in China, page 20,) and it must be remembered that a rifled shot has no advantage in momentum over a rifled shell of the same weight and calibre. No doubt there is economy in using shot for practice.

Drill shot.

2. DRILL SHOT.

Shot, rifled, B.L. drill (12, 9, and 6 prs. only, entered in vocabulary).

Patterns of drill shot⁴ for 7" 40, 20, 12, 9, and 6 prs. were sealed on January 3rd, 1863, consisting of solid shot with a sufficient amount of the lead coat turned off to enable them to pass freely through the bores of the guns,⁵ but on July 8th, 1864, a pattern shot,⁶ with the lead coat continued entirely over the head, was approved for 12-pr. guns, it having been found that with the 12-pr. rifled-gun, which had a wider slot than the previous pattern, the head of the shot dropped sufficiently for the iron to strike and injure the lower part of the copper bush.⁷ On May 6th, 1865, a shot⁸ similarly covered over the head was approved for the 9-pr. gun.

On February 12th, 1869,⁹ 7" 40-pr. and 20-pr. drill shot were done away with; recovered common shell, with the coats sufficiently removed, being directed to be used for drill purposes, except for 12-pr., 9-pr., and 6-pr. guns, which retain their drill shot.

General marks of identification.

Drill shot, which have the lead over the heads, are at once identified by the head, all drill shot have no cannellure, and are apt to have a want of finish about the coat; those made from recovered projectiles may show

¹ *Vide* Changes in War Stores, § 344.

² " " " 405.

³ " " " 477.

⁴ " " " 724.

⁵ The maximum diameters at the bases are 7", 6"·975; 40-pr., 4"·730; 20-pr., 3"·710; 12-pr. and 9-pr., 2"·970; 6-pr., 2"·480.

⁶ *Vide* Changes in War Stores, § 942.

⁷ Failing the proper drill shot a turned down common shell might be tried, as its great length might prevent its dipping.

⁸ *Vide* Changes in War Stores, § 1088.

⁹ " " " 1742.

the marks of the grooving on them, in spite of the removal of lead ; it will therefore seldom be necessary to gauge them for identification.

CASE SHOT, 7", 64-pr., 40-pr., 20-pr., 12-pr. or 9-pr., and 6-pr. Calibres.

Case shot for the service rifled guns were proposed by Lieut. Reeves in 1863, the segment shell, even with the time fuze composition pricked through at zero, not being considered effective as case. The chief difficulty in designing case for rifled guns, especially on the polygrooved system, is to overcome the liability to injure the bore, and yet to ensure the case breaking up properly. Further, conglomeration of bullets may occur in the case of lead balls, or, on the other hand, too wide dispersion. Lastly, the case for field guns must be such as will travel well in limber boxes.

Lieut. Reeves proposed case shot containing lead and antimony balls for the smaller calibres and sand shot for the larger, packed with buck shot, rosin being run in to fill up interstices and bind the whole together (compare with 9-pr. M.L. case, p. 99). Also another pattern, in which the case shot were packed by being let into discs of sycamore wood, which were weakened by being partly sawn through. The envelope of the case was tinned iron, and had solder studs at the base to make it stop at the shot chamber on ramming home.

On these case the Committee reported very favourably, and a pattern was adopted with wood discs, but for large calibres with much larger balls¹ than were advocated by Lieut. Reeves, who always maintained that small sand shot and musket balls,² made up with buck shot, were much more effective than large ones, both against troops and boats, for short ranges;³ while at long ranges shrapnel would give greater effect. Buck shot he considered very deadly up to about 50 yards range. He preferred employing rosin or sawdust inside a lining of pieces of wood placed longitudinally, to wood discs, which prevented the use of buck shot.

General Boxer, then Superintendent of the Royal Laboratory, who had designed a pattern of case shot employed with great success by Mr. Whitworth in the Armstrong and Whitworth trials, and considered by that committee superior to Reeves' pattern, suggested the employment of an inner case or lining of iron segments,⁴ the balls being packed in coal dust. He, like Lieut. Reeves, opposed the use of the large balls, stating that he found that 6-oz. sand shot penetrated some six or seven inches into solid teak at 200 yards when fired from the 7" gun, showing them to be sufficiently destructive for boat service, besides possessing advantages in point of number over the 8-oz. balls.

¹ The 7" B.L. and M.L. case had 1-lb. balls, and the 9" M.L. 2-lb. balls.

² Lieut. Reeves, in a letter 10/6/67, recommends for field guns 1-oz. mixed metal balls and buck shot; 20 and 40 pr. guns, 2-oz. mixed metal balls; all larger natures, 4-oz. sand shot.

Superintendent of School of Gunnery, General Wilmot, endorses this recommendation, 12/6/67.

Captain Hood recommends, 10/12/66, 6½-oz. balls for 7" and 64-prs., and 2-oz. lead balls for the 20-pr.

A minute from D.G.N.O., 18/12/66, also recommended trial of smaller balls, as recommended by Superintendent Royal Laboratory.

³ W.O. Minute to Ordnance Select Committee, 19/12/66, says, "The navy will not return to grape, the utmost required of case being to penetrate a boat at 400 yards, which the present pattern does with ease."

Letter from Lieut. Reeves, 10/6/67, says, "Late experiments have clearly shown that the great use of case will be at very short distances. At and beyond 300 yards shrapnel shell or other projectiles would be much more destructive."

⁴ In a letter written 1/11/66.

This pattern, known as the Laboratory pattern, was introduced both for breech and muzzle loading rifled guns, but the Committee eventually superseded the 6-oz. by 8-oz. sand shot.

Rule as to
weight of case
shot.

As to weight, the Committee on Aug. 16th 1866¹ decided "the total weight of the projectile for guns above 7" calibre to be regulated by the weight of the round shot of the calibre, one or two being used, according to distance, with full charges; for 7"-guns and under, the weight to be three-fourths that of the rifled projectile.¹ This latter rule, therefore, governs the case for all breech-loaders.

Double rounds of case could only be used in B.L. guns by removing the studs of the front one, and this is not contemplated.

The present service patterns of case shot for B.L. guns are as follows :—

Calibres—7", 64-pr., 40-pr., 20-pr., 12-pr., 9-pr., and 6-pr.

For larger calibres (7", 64 and 40 prs.) the case is sheet iron with fringed ends. An iron bottom is riveted to the lower fringe, on which rests a wrought-iron disc; on this stands a lining of three wrought-iron curved plates or segments; within are sand shot (8 oz.) packed in coal dust and covered with an iron top fringed and soldered down. The 7" and 64-pr. have an iron handle.

Smaller calibres, 20-pr., 12-pr., 9-pr., and 6-pr. have each a tinned iron case with tin bottom and iron disc laid inside, and an iron bottom riveted to the outside; also a wood top, zone-shaped (to facilitate loading), covered with tin. The 20-pr. has 4-oz. balls, the 12 or 9 pr. 2-oz. balls, and the 6-pr. 1 oz. balls, all of iron.⁴

The larger calibres (7", 64 and 40 pr.) have solder studs; the smaller calibres solder rings divided in four places at base, to prevent them being pushed too far up the bore of the gun.

The 7" case shot, both Reeves' and Laboratory pattern, is made to suit both M.L. and B.L. 7" guns by having three large solder studs at one end, which cause it to stop in the shot chamber when ramming home in a B.L. gun, but find room in the three deep grooves of the Woolwich gun. This plan is not applicable to the 64-pr., for the calibre of the B.L. 64-pr. wedge gun is 6·4", while that of the M.L. shunt gun is only 6·3".

The details of pattern of case for B.L. guns are as follows :—

7-inch Case B.L. and M.L.

1st. Approved provisionally 29/6/66, to meet urgent wants for both B.L. and M.L. guns. Reeves'² pattern, now in Royal Laboratory; length laid down, 22" (limits ± 1 inch); weight, 102 lbs.³ ($\pm 1\frac{1}{2}$ lbs). With thin sheet iron case having the three large solder studs placed on the end with the handle on it; this case being loaded handle to the rear with B.L. guns, but with M.L. guns it would probably be more convenient to turn the handle and studs to the front. It contains 87 sand shot of 1 lb. packed in 12 wood discs; marks on top, I. W \wedge D, 7 In. M.L. or B.L.

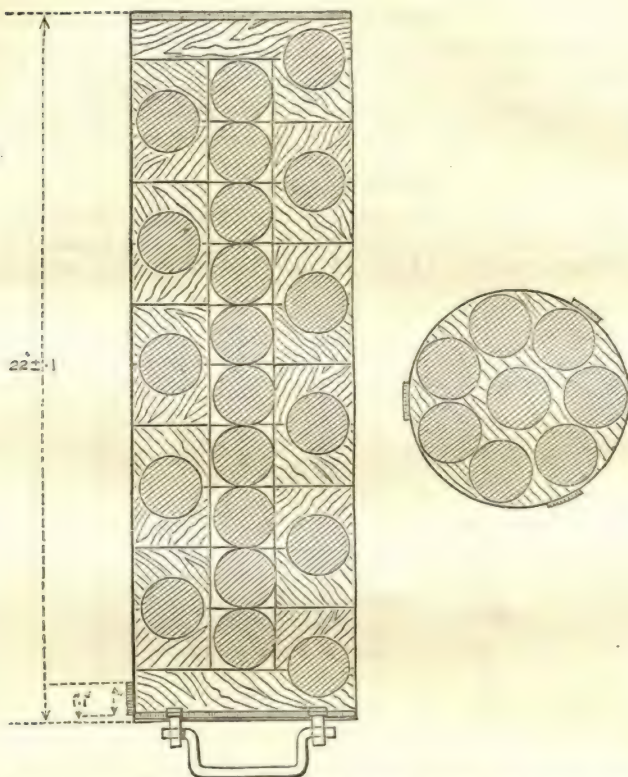
Shot, rifled,
B.L. case,
7-inch.

¹ Vide letter to Superintendent, Royal Laboratory, 16/8/66, and Min. 19,499; also Extracts, vol. iv., page 398. Also they recommended 8 oz. to be the standard weight of balls for all case for rifled guns above 20-pr., 4 oz. for 20-pr., 2 oz. for 12-pr. and 9-pr., and 1 oz. for 7 and 6 prs.

² Vide Changes in War Stores, § 1241.

³ The weight of case shot is very liable to variation. Those here given are the mean weights laid down. The sealed patterns generally run close to the same.

⁴ The diameters of the case shot are as follows :—7" 6·89" 64-pr., 6·3" 40-pr., 4·715" 20-pr., 3·705 12 or 9-pr., 2·95" 6-pr., 2·465.



2nd. By authority 21/11/66,¹ 57/24/4398. Placed in Royal Laboratory pattern room (but never sealed) to govern some very limited supplies for M.L. and B.L. guns. Length, 10·4 inches; weight, 67 lbs. (limit ± 2 lbs.). The case is sheet iron with iron ends, segments, &c., as in general description above; also three large solder studs at base. It contains 112 sand shot of 6 oz., 23 mixed metal musket balls, 22 mixed metal pistol balls, packed in coal dust. Marks on top, II. W \nearrow D, 7 In. M.L. or B.L.

3rd. Approved 24/3/68.¹ Pattern in Royal Laboratory. Length, 10·25"; standard weight, 67 lbs. (± 2 lbs.). The case resembles the last, but the segments are thicker. It contains 74 sand shot² of 8 oz., the weight of case and segments being about 26 lbs. 2 oz., and of coal dust 4 lbs. 9 oz. Marks, III. W \nearrow D, 7 In. M.L. or B.L.

64-pr. Case Shot (B.L. only).

Of this there is only one pattern, approved 24/3/68.¹ Pattern in Royal Laboratory. Length, 9 inches; standard weight, 48 lbs. ($\pm 1\frac{3}{4}$ lbs.). It is the "Laboratory pattern," with sheet iron case, segment lining, &c. described above; it has six solder studs at base. It contains 56 sand shot of 8 oz.; the case and ends and lining weighing about 17 lbs. 2½ oz., and coal dust about 3½ lbs. Marks on top, I. W \nearrow D, 64-pr. B.L.

Shot, rifled,
B.L. case,
64-pr.

¹ *Vide* Changes in War Stores, § 1611.

² The sand shot generally run rather under their nominal weight; in this pattern they weigh 36 lbs. 5 oz.

Shot, rifled,
B.L. case,
40-pr.

40-pr. Case Shot.

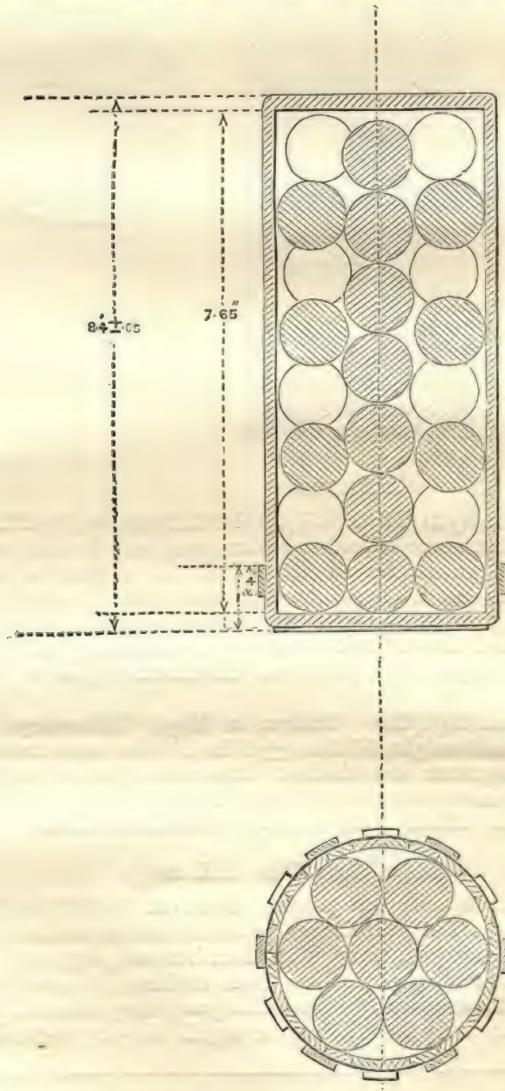
Approved 24/3/68.¹ Pattern in Royal Laboratory. Length, 10·1 inch; standard weight, 30 lbs. (\pm lb.). It is the "Laboratory pattern," with sheet iron case, segments, &c.; it has 24 studs placed in two rows at the base. It contains 37 sand shot of 8 oz. Marks on top, I. W \nearrow D, 40-pr. B.L.

Shot, rifled,
B.L. case,
20-pr.

20-pr. Case Shot.

Of these there are two patterns, both now Royal Laboratory.

1st. Approved provisionally 25/9/66.² Length, 8·4 inches (\pm ·05 inches; standard weight, 14 lbs. 14 oz. Reeves' pattern, with wood



¹ *Vide* Changes in War Stores, § 1611.

² *Vide* Changes in War Stores, § 1299.

lining and sawdust; it has studs on the base. It contains 55 mixed metal bullets (4 oz.), weight 13 lbs. 12 oz.; and wood lining, weight 6 oz. The case weighs 12 oz. Marks on top, I. W \wedge D, 20 Pr. B.L.

2nd. Approved 22/3/68.¹ Length, 9.3" \pm .1"; standard weight, 15 lbs. (\pm 12 oz.). "Laboratory pattern;" with tinned case, lining, and zone wood top, given in general description above. It contains 41 sand shot of 4 oz., weighing 9 lbs. 12½ oz.; the weight of case, with its lining and the coal dust, being 4 lbs. 8 oz. and 11½ oz. respectively. Marks on top, II. W \wedge D, 20 Pr. B.L.

12 or 9 pr. Case Shot.

Approved provisionally 9/8/66.² In Royal Laboratory. Length, 10.5 inches; weight, 12 lbs. 8½ oz. Reeves' pattern; tin case, with wood discs and flat top. It contains 77 mixed metal balls (seven to the lb.), and 12 wood discs. Marks on top, I.

Shot, rifled,
B.L. case (12
or 9 pr. not in
vocabulary).

12-pr. Case Shot.

Approved 9/8/67,³ but never sealed; (pattern is in Royal Laboratory), a few only being made for 12-pr. guns. Length of pattern, 6.9 inches; weight, 9 lbs. 4 oz., about. Is "laboratory pattern," with iron lining and zone top, &c. (its case is single thickness). It has 12 studs in two rows at base. It contains 70 mixed metal balls (of 1½ oz.). Marks on top, II. W \wedge D, 12 or 9 pr., being marked wrongly.

Approved 24/3/68⁴ (Pattern in Royal Laboratory). Length, 8.5 inches (\pm .1 inch); standard weight, 9 lbs. \pm 8 oz. It is laboratory pattern, with iron lining, zone wood top, and solder divided ring at base, &c. It contains 48 sand shot (of 2 oz.). Marks on top, III. W \wedge D, 12-pr. B.L.

9-pr. Case.

Approved 29/1/70⁵ (Pattern in Royal Laboratory). Length, 6.85 inches; standard weight, 6 lb. 9½ oz. It is the laboratory pattern, with iron lining, zone top, &c., and divided solder ring at base. It contains 35 sand shot (of 2 oz.). Marks on top, II. W \wedge D, 9-pr. B.L.

Shot, rifled,
B.L. case,
9-pr.

6-pr. Case.

⁶ 1st. A few shot were issued to Jamaica on urgent demand in December 1865 as pattern I., but no circular was promulgated, and no sealed pattern exists.

2nd. Approved provisionally⁷ 25/9/1866. Length, 5.8 inches; standard weight, 4 lbs. 4 oz. It is of the Reeves' pattern, with wood lining, having 12 solder studs at base; it contains 61 mixed metal balls of 1 oz. and one of ¼ oz. weight packed in saw dust. Marks, II. W \wedge D, 6-pr. B.L.

Shot, rifled,
B.L. case,
6-pr.

On looking at the details of these more recent patterns one can hardly fail to be struck by the disproportionate weight of the case and lining compared with that of the balls, for instance, in the 64-pr. III., the sand shot weigh 36 lbs. 5 oz. and the case and lining 26 lbs. 2 oz. This case happens to be an unusually heavy projectile, and does not at all conform to the rules laid down by the Committee, and therefore the

¹ Vide Changes in War Stores, § 1611.

² " " " § 1242.

³ " " " § 1467. Only issued for sea service, besides a few for artillery practice.

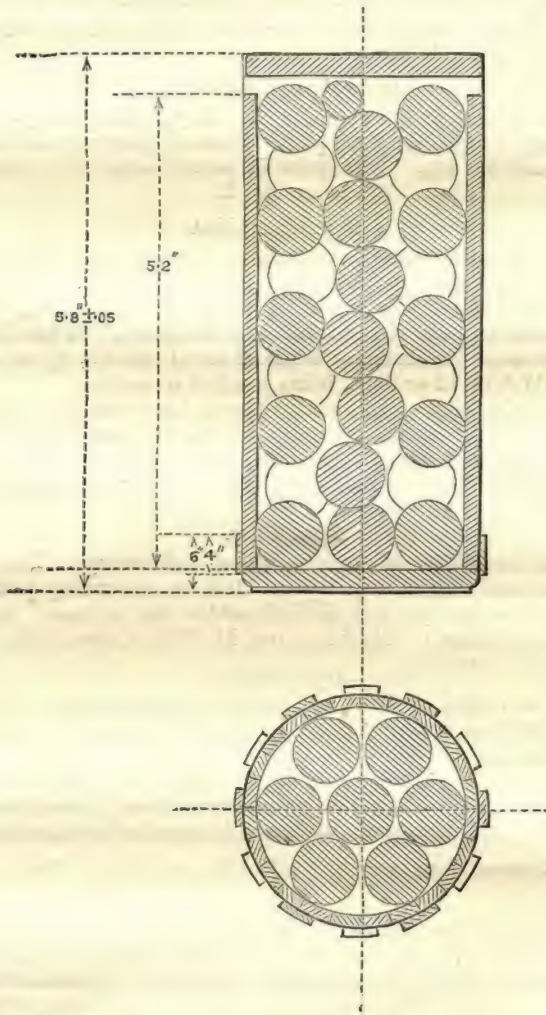
⁴ Vide Changes in War Stores, §§ 1611 and 1900; the latter directs that all previous patterns be called in and replaced by Mark III.

⁵ Vide Changes in War Stores, §§ 1867 and 1900; the latter directs that all previous patterns of 9-pr. case be called in and replaced by Mark II.

⁶ Vide note on Changes in War Stores, § 1299.

⁷ Vide Changes in War Stores, § 1299.

actual charge of balls stands more in proportion to the weight of the other projectiles of the gun than is the case of the 20-pr., whose case shot II. contains only 9 lbs. 12½ oz. of balls, although its exterior case and lining are comparatively light, viz., 4 lbs. 8 oz., the total weight of the projectile being in accordance with the Committee's system, *vide* note and text, page 44.



REEVES' B.L. CASE 6-PR., II.

The construction of case for rifled ordnance is a problem that can hardly be considered to have been worked out satisfactorily as yet. In fact the doubt can scarcely fail to arise whether both expense and also injury to the bore may not have been too much considered; some may question the policy of saying that we cannot afford to fire lead and antimony balls at an enemy within 300 yards of our guns, and yet even the 9-pr. has had iron sand shot substituted; again no targets represent the wide spread of troops when closing on guns, and therefore it is possible that under such circumstances Reeves' case might act better

than the laboratory pattern, which carries closer, but has much less weight of balls, (for instance, the 20-pr. Reeves' case has 4 lbs. more balls than that of the laboratory pattern).

Paint, black.

Paint.
Issue.

Case shot are issued loose, but those in tin cases, viz., 20-pr. and smaller calibres, are packed in boxes for transit.

It should be borne in mind that case shot are employed only at critical moments; any serious discussion therefore as to slight fouling of the gun¹ appears quite out of place; it is also doubtful if any increase to the smoke either from rosin or coal dust is a disadvantage, for the general use of case is at troops within 300 yards, and therefore the more completely the guns and men are concealed the better, and with a gun (not mounted any height above the plain) firing on open formations of troops on level ground, case is not a projectile requiring very careful aim or elevation; the Committee indeed note on practice carried on 29/1/66 that "on smooth ground it is best to fire with no elevation, as the bullets "run along the ground. When elevation is given the bullets bound a good "deal, and unless the exact elevation is given the effect of many is lost."

Use of case
shot.

Officers can hardly have it too strongly impressed on them that the effect of case shot depends chiefly on its ricochet, and what is given as its range is commonly the limit of its effective ricochet on hard flat ground.² Infantry could probably advance in the teeth of guns firing case over boggy ground, or even very broken ground with comparatively small loss; in such cases careful aim and elevation would be necessary, and then it is a question whether shrapnel ought not to be preferred. It would appear also that any advantage possessed by large balls would specially depend on the nature of the ground in front of the guns, and even in the case of heavy guns mounted in fortresses where the ground may be suitable to an extended range, the enemy would hardly break from their trenches at 300 yards from the place.

Case shot are to be loaded with the studs to the rear in all cases, so as to keep the two iron discs behind the balls to carry them well forward, except with the 7" Mark I. in M.L. guns³ which may be entered as most convenient.

¹ Lieut. Reeves informed me that both possible fouling and smoke had been urged as objections to the use of rosin with buck shot in place of wood discs.

² The effect of the case and grape fired on the English advancing on the Redan on September 8th, 1855, in the siege of Sebastopol, was such as will not readily be forgotten by those who saw it; the ground was fairly level, hard, and very dry. I happened to be in a battery well placed for view, and being ordered to discontinue my fire as the troops advanced I had full opportunity of watching the effects; each gun flash from the flanks of the work was followed by puffs of dust commencing perhaps 50 yards from the muzzle, and running along the ground in an accumulating shower which died away at some hundred yards distance, some stray grape of large size even ringing on the stony ground and entering batteries 1,000 yards from the Russian works. A few rounds fired nearly simultaneously sufficed to sweep and regularly dust the ground, and gradually as the attack continued it became dotted with the bodies of men.

The effects of the grape and case on June 18th over the same ground were very much greater, both the Generals leading the attacks, viz., Sir J. Campbell and Yea, and a large number of the men, being killed in a few minutes; the column led by the former officer suffered chiefly from case and grape. I missed seeing this attack, but conclude the effect was increased simply from the fact that there were a large number of Russian guns neither dismounted nor silenced.

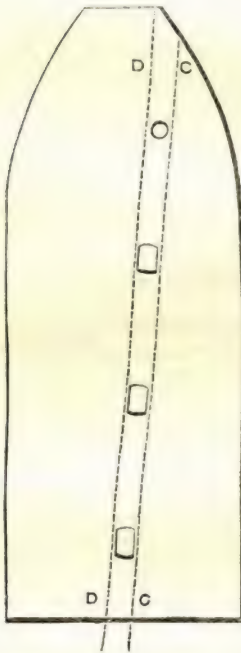
³ Much confusion exists as to which end of each pattern of case shot should be placed to the rear (*i.e.* next the charge) in loading. The following is the rule for large calibres both for S.B. and rifled guns.

The handle to be to the front in all cases except with the patterns with rope handles and I. Reeves case in 7-inch B.L. gun; the former having the rope in its stronger end and the latter having its studs at the handle end.

SECTION II.

MUZZLE-LOADING ARMSTRONG, SHUNT SYSTEM.

The *shunt system*, of which the 64-pr. is the only example now in the service, has been considered inferior to the Woolwich, because besides being unnecessarily complicated, the grooves which are cut with abrupt sharp angles weaken the gun.¹ The principle is as follows :—The studs of the shell bear on the deep side of a double groove on entering, and on the shallow side on leaving the bore, thus loading easily, yet leaving the muzzle tightly gripped with a stable axis. This may be easily explained :—A rifled projectile, both on entering and leaving the bore, is driven by a force acting along its axis, and rotation is given by the stud coming against the spiral formed by the edge of the groove, thus



in figure, if the projectile were pushed base first, the stud A would move against the loading edge C C of the groove, while if pressure were applied to the base so as to move it point first, the studs would meet the driving edge D D and work along it; in the shunt gun, however, in addition to the mere fact of the driving side of the double groove being shallow, and the loading side deep, the two grooves join in one deep one at 2 feet 7·5 inches from the muzzle, each stud thus running down the deep side into the common groove, and returning up the common groove and shallow side, just as a railway engine shunts from one line to another by backing on a common piece, into which both are made to lead. The shallow groove does not break with an abrupt step into the single groove, but by a gradual incline, the exact details of which belong to the gun factory. It may be noticed also that at the bottom of the bore, one groove is made to narrow slightly so that after running along the loading edge, each stud is brought to touch the driving edge just at the bottom of the bore; this saves it from bounding on to it with a blow on the first impulse from the charge.

The studs are of copper; there were formerly five, but now three only to each groove; they are attached by swedging or staving into undercut holes; their form is cylindrical with the sides bevelled off to a certain extent.

The calibre of this gun is 6·3".

¹ In the case of the two guns which burst, the steel tubes split in the direction of the sharp angles of the grooves, and the Committee are inclined to think that the angular form of the groove in the shunt system, for the greater part of the length, may possibly have promoted the ultimate disruption of the tubes. The Woolwich form of groove is free from the defect due to sharp angles. The Superintendent Royal Gun Factories, in a letter to the Ordnance Select Committee, attributes the failure of the 13" gun, among other causes, to the gun having been rifled on the shunt system.—Vide *Ordnance Select Committee Reports*, vol. v., p. 99.

The dimensions of grooves and studs are as follows :—A section of the deep groove gives a depth of $\cdot 11$ inches, width at bottom $\cdot 6''$. The incline of the edges is given by tangents drawn from each side of the groove to a circle concentric with the bore $1\cdot 7''$ radius. The shallow or "pinching" groove whose driving edge is in the production of that of the deep groove (*i.e.*, at a spiral of 1 in 40 calibres), decreases in depth by $\cdot 025''$ in the first $12\cdot 6''$ incline, and by $\cdot 005''$ the next $12\cdot 6''$, from which it runs at a constant depth of $\cdot 08$ to the muzzle, where the deep groove has so far shunted from it as to give a step or shallow groove $\cdot 4$ inches wide. The width of the stud is $\cdot 55$ inches, so that it must always partly extend over the deep groove. The height $\cdot 125''$ shows that for any part to enter the shallow groove it must undergo a compression or wearing down of $\cdot 01$ inch.

The windage over the body of all shunt projectiles is $\cdot 08''$.

As to the proportions of the projectile.—Those most recently sealed are brought to conform as nearly as possible to the principle laid down for Woolwich projectiles, the exact details being given individually below.

N.B.—The shunt system being discarded and likely to die out, it seems preferable to discuss all questions as to rate of twists, length, shape of head, &c., under the heading of Woolwich system, also to keep the shunt projectiles entirely by themselves, so that they may be readily expunged without involving complicated corrections throughout the pages treating of M.L. projectiles.

ARMSTRONG SHUNT PROJECTILES.

(a.) SHELL.

Armstrong
shunt projec-
tiles.

The only 64-pr. M.L. shells now in the service are,—¹

- 1st. Common.
- 2nd. Shrapnel, Boxer.

The common shell which is naturally compared with the 64-pr. B.L. Shell, rifled, shell differs from it in the following respects,—First, in not being lead coated and in having three spiral rows of copper studs (pitch 1 in 40 calibres). The present pattern has three studs in each row, riveted into undercut holes. M.L. common
64-pr.

2ndly. The calibre of the shunt gun is $6\cdot 3$ inches instead of $6\cdot 4$ inches, the diameter of the M.L. shell being $6\cdot 22''$; and that of the body of the B.L. shell $6\cdot 43''$.

3dly. Three small extractor holes are made in the head, one in prolongation of each row of studs.

Pattern IV. shell to govern future manufacture has an unloading hole $\cdot 75''$ in diameter closed with a metal screw plug, and papier mâché wad beneath.²

As with the B.L. shell the fuze hole is bushed, formerly to the Moorsom gauge, now to the General Service gauge, new shells being made with the G.S. fuze hole, and old ones having the G.S. adapter permanently fixed in. *Vide* page 17.

Fuzes.—Were $7\frac{1}{2}$ and 20 seconds metal and Pettman's S.S. percussion Fuzes, for O.P. shells.

The present pattern shells (or O.P. with adapters) take Boxer 9 or 20 seconds M.L.O. or Pettman's G.S. fuze.

¹ For obsolete projectiles, viz., segment shell and hollow shot, see p. 54.

² *Vide* Changes in War Stores, § 1760, 23/3/69.

Details of Patterns.

Shell, rifled,
M.L. common,
64-pr.
Details of pat-
terns.

There are four patterns deposited in the Royal Laboratory, all have conoidal heads with three extractor holes, and all have bottoms cast solid, being manufactured in the Royal Laboratory.

They are as follows :—

1st pattern.

1st Pattern.—Approved provisionally 3/12/64;¹ length, 14·71" ; standard weight, 59 lbs. 8 oz. Round bottom, with small hole in centre, closed with lead ; black lacquer ; studs, five in each row ; Moorsom gauge bush, with a recess ·9" deep ; capacity for bursting charge (4 lbs. 8 ozs.) about. Marks. I between one extractor hole and row of studs, on base R L.

Marks.

2nd pattern.

2nd Pattern.—Approved provisionally 4/1/67 ;² length, 16·0" ; standard weight, 57 lbs. 9 oz. ; flat bottom ; black lacquer ; studs, three in each row ; Moorsom gauge bush, with ·9" recess ; capacity for bursting charge, 7 lbs. Marks. II. R \wedge L between an extractor hole, and

Marks.

row of studs, on base R L.
B.

3rd pattern.

3rd Pattern.—Approved, 18/2/67 ;³ length, 16·0" ; standard weight, 57 lbs. 9 oz. ; flat bottom ; red lacquer ; studs, three in each row ; general service bush, with a recess ·2" deep ; capacity for bursting charge, 7 lbs.

Marks.

III. Marks. R \wedge L between an extractor hole, and row of studs, on base R L.

4th pattern.

4th Pattern.—Approved, 17/2/69 ;⁵ length, 16·0" ; standard weight, 57 lbs. 9 oz. ; flat bottom ; red lacquer ; studs, three in each row ; general service bush, with recess ·2" deep ; capacity for bursting

Marks.

charge, 7 lbs. Marks. IV. R \wedge L between an extractor hole and row of studs on base R L.
B.

N.B.

This shell has an unloading hole and screw plug.
N.B.—It will be noticed that this shell differs in construction from that known as III. only in having an unloading hole.⁹

Paint.

Paint.—All are painted black, except the studs.

Issue.

ISSUE OF COMMON SHELL.

1st. Filled.

1st. Filled.

Were formerly issued for sea service, filled and fuze with Pettman's S.S. fuze.

All issued since 27/10/66 being marked⁶ "FILLED" in red letters, and such as are issued since 24/3/70 would have the date and R \wedge L and W also in red.⁷

All shells issued filled since 5/8/67⁸ have either G.S. adapters fixed in the fuze hole, or have G.S. gauge fuze holes, and have Pettman's

¹ *Vide* Changes in War Stores, § 1042.

² Changes in War Stores, § 1393.

³ " " " § 1394.

⁴ The sealed pattern has an unloading hole, added at first, but afterwards covered over, it being decided that this change should be accompanied by a change of pattern.

⁵ *Vide* Changes in War Stores, §§ 1768 and § 1764.

⁶ " " " § 1349.

⁷ " " " 1880, also p. 17, and note 2.

⁸ " " " 1238.

⁹ " " " § 1764, which states that unloading holes are introduced to prevent the danger of using force with a percussion fuze, *vide* appendix.

G.S. fuzes fixed in them. Shells with unloading holes would have papier mâché wads in the unloading holes beneath the unloading hole screw plugs.¹

Filled shells are placed in jute bags, for protection in transit, marked "64-pr. M.L. filled."

2nd. Empty.

2nd. Empty.

Formerly with screw plug, Moorsom gauge, for land and sea service.

Shells issued since 5/8/67 have either G.S. adapters fixed in them or G.S. fuze holes, and have G.S. screw plugs.

All shells issued empty for sea service between 28/2/66² and 30/11/66³ had kit plasters over the fuze hole recess, and all since the latter date have blue-waxed wads in the recesses over the screw plugs, to distinguish them more readily from filled shells.

N.B.—Unloading holes are well oiled, and papier mâché wads are inserted beneath the screw plugs in all cases, that is whether the shell is issued empty or filled.

Experience.—See p. 72.

2. SHRAPNEL BOXER, 64-PR.

Shrapnel Boxer.

The principle of construction of this shell is identical with that of the Boxer shrapnel for 64-pr. B.L., even to the extent of having a wood cylinder round the central tube.

It differs from the B.L. shell however in the following particulars:—

1st. In not being lead coated, and in having three spiral rows of copper studs, pitch 1 in 40 calibres, three studs in each row, attached by riveting into undercut holes; there is no countersink round each stud of this shell, such an arrangement having been found unnecessary.

2nd. In calibre and dimensions. As noticed in the case of the common shells the calibre of the shunt gun is 6·3", and that of its shell 6·22", while that of the B.L. gun is 6·4", and of the body of its shell 6·43".

The M.L. shell is about half an inch longer than that for the B.L. gun, and the dimensions of all its parts are affected proportionally.

3rd. It has three extractor holes in its head in prolongation of the three rows of studs.

4th. It contains 234 lead and antimony bullets instead of 224.

It has the same socket with G.S. bush as the B.L. shell, but it takes the 9 secs. M.L.O. fuze as its service fuze.

It is readily distinguished from the common shell by its projecting socket, and also by the shoulder or lip at junction of head and body.

The details of the patterns of this shell are as follows:—

Shell, rifled,
M.L. Shrapnel
Boxer, 64-pr.
Details of pat-
terns.

1st. Approved provisionally 26/1/67.⁴ Length, 14·02". Actual weight, 63 lb. 12 oz. Bursting charge, 5 oz. It contains a cast-iron diaphragm resting on three flanges in the powder chamber, with the gutta-percha disc and marine glue lining. Marks, $\begin{smallmatrix} R \nearrow L \\ 1. \end{smallmatrix}$ on body, "5" Marks, from the shoulder.

2nd. Approved 21/3/68.⁵ Length, 14·1". Standard weight, 64 lbs. 8 oz. Bursting charge, 5 oz. It contains a wrought-iron diaphragm and tinned iron lining to powder chamber. Marks, $\begin{smallmatrix} R \nearrow L \\ II. \end{smallmatrix}$ on body about "5" from the shoulder.

These shells are painted black, except studs and projecting socket. Paint.

¹	Vide Changes in War Stores,	1517.
²	"	1190.
³	"	1346.
⁴	"	1424.
⁵	"	1609.

Issue.

Issue.

1st. Filled, and with primer inserted and screw plug, placed in jute bag,¹ shell and bag marked "Filled" R \nearrow L & W in red paint.

2nd. Empty, with screw plug.

For use and experience, *vide* pp. 72, 73.

Not in vocabulary.

In addition to the shells now in the service for the 64-pr. M.L. gun there have been segment shell made, but they have all been broken up.

Segment shell.

SEGMENT SHELL.

Approved ² 2/12/64. Length, 12·21". Standard weight, 62 lbs. 2 oz.
³Capacity for bursting charge, 1 lb. 15 oz. Conoidal head with three extractor holes, slightly rounded bottom, with flat rim; there are four studs in each row in countersunk holes; the fuze hole recess is ·9" deep.

Marks.

Marks, I. between one extractor hole and row of studs, RL on base. The bursting charge was 1 lb. 1 oz.

(b.) SHOT.

Case shot are the only class of shot now in the service for 64-pr. M.L. guns.

It is of the so-called Royal Laboratory pattern, with iron segmental lining and coal dust, described on p. 43, 44; it differs however from the 64-pr. B.L. case in the following particulars:—

1st. In calibre and other dimensions. The calibre, differing in accordance with the difference in the bores of the guns, prevents the same case being interchangeable; the diameter of the M.L. case is 6·2 inches, and that of the B.L. 6·3 inches. Other dimensions are of course affected by this, the M.L. case is ·6 inches longer than the other.

2nd. It has no solder studs at the base.

3rd. It contains 56 sand shot (8 oz.) instead of 58.

The details and dimensions of the pattern are as follows:—

Shot, rifled,
M.L. case,
64-pr.

Approved 24/3/68.⁴ Length 9·6". Weight, 48 lbs. Iron handle in the top.

	lbs.	ozs.
It contains 56 sand shot, 8 oz., weight	-	27 6
The weight of case and segment is	-	17 $2\frac{1}{2}$
The weight of coal dust	-	3 $7\frac{1}{2}$

(Standard weight) Total	-	-	48 0
-------------------------	---	---	------

Limits \pm 1 lb. 12 oz.

Marks on top I. W \nearrow D. 64-pr. M.L.

In loading the handle of this case shot should be kept to the front. Paint, black. Issue, loose.

Use.

A hollow-headed shot² was approved provisionally for this gun on December 3rd, 1864, and made obsolete, 28/11/66.

¹ *Vide* Changes in War Stores, \S 1517.

² " " " " \S 1042.

³ Given as 1 lb. 14 oz. in \S 1042; corrected to 1 lb. 15 oz. in \S 1116.

⁴ *Vide* Changes in War Stores, \S 1611.

⁵ " " " " \S 1190.

Its details are as follows :—Length, 13". Standard weight, 64 lbs. It has a conoidal head plugged with iron at the apex, three extractor holes, flat bottom, three rows of studs, five in each row, in countersunk holes. Marks, I. between extractor holes and row of studs, and R L on base.

N.B.—It would be at once recognised by its absence of fuze hole.

Uniform spirals.

gun and consequent wear¹ is less; it also has a slight advantage in accuracy of fire, although a rather lower initial velocity. In accounting for these effects with the increasing twist, it may be well to consider very briefly the entire question.

The object is to get the maximum velocity that can be given to the shot without imposing an intolerable strain on the gun. Now, as noticed before, with large calibres the main difficulty is to keep this strain and consequent wear and tear on the gun under control; that is, to make the piece last a reasonable time. Hence it is desirable to attain this end, even at the sacrifice of powder, and this is precisely what is effected by the adoption of the increasing twist, instead of the uniform; for on the latter system the projectile can only move forward after rotation has been imparted to it by the indirect resistance of the driving edges of the grooves against the studs; in fact, after resistance to rotation as well as inertia has been overcome, while with an increasing twist the projectile moves forward as soon as its inertia is overcome, and the rotation is imparted gradually during its passage through the bore.

To compare the two systems it is advisable to take the case of projectiles leaving both guns with the same velocity, when, it stands to reason, both shot having the same "work done" on them, both guns must also have the same "work done" on them, and the entire value of the increasing system depends on the shape in which this work is performed. Now it appears that "work" may be "done" on the particles of the mass among each other, or equally on the whole as a rigid body; thus, when the force acts too quickly to develop any recoil, it is obvious that it has acted on the particles among themselves, which may be supposed to be vibrating from elasticity, or else permanently crushed, and this may be considered generally to be the nature of destructive effect; but when a force acts more gradually on a gun, the whole mass recoils more rigidly, and less destructive effect takes place; in short, the "work done" on a gun is shown by recoil and destructive effect; and the more gradually the work is performed, in plain words, the more it becomes a push rather than a blow, the more recoil and the less destructive effect is produced.

This, then, is the nature generally of the work developed by an increasing as compared with a uniform twist, and it is reasonable to conclude that where comparison was made in the cases of two projectiles of equal initial velocity, the gun with the increasing twist would have the greater recoil.

This method of performing the work gradually, by the increasing spiral, however, necessitates the expenditure of more powder, because the shot moving more readily, less gas is generated before it commences to move, and since the pressure of this gas is in inverse proportion to the space it occupies, it acts with less and less power as the space behind the

¹ "It will be seen that in point of accuracy of fire, taken on a general average, the increasing spiral has the advantage, the uniform spiral gun has a higher initial velocity and consequent length of range, but the difference is not sufficient to be of any practical importance. Being still persuaded that the theoretical reasons in favour of an increasing twist are sound ones, that a system of rifling which admits of the projectile moving directly forward from its seat at the moment of ignition of the charge must be more favourable to endurance than one which, by impeding the first movement of the shot in the bore, narrows the space for the expanding gas, and consequently brings a greater pressure on the breech of the gun, the Committee as a body have no hesitation in recommending that it be adopted for 8-inch guns of 9 tons, and combined with four grooves of the Woolwich form, viz., width, 1·5 inches; depth, ·18 inches. Mean initial velocities, increasing 1303·3 feet a second. Uniform, 1338·6". — *Vide Ordnance Select Committee Extracts*, vol. iv., p. 253, 2/7/66. Also opinion repeated, vol. iii., p. 325, and vol. v., p. 18.

shot gets larger and larger, and in addition to this, the shot being already in motion, the pressure becomes dependent on the difference between the velocity of the gas itself and that of the projectile in front of it.

Every increasing spiral in the service is what is termed "uniformly gaining;" that is, suppose the bore to be cut across into any number of equal lengths, each successive one as the shot passes through it gives the same addition to the twist.¹ Uniformly increasing spiral.

Before entering into details as to the studs and grooves, it may be remarked that the work they perform may be limited to imparting rotation to the projectile, or it may include giving it direction also, according to whether there is more windage over the top of the stud in the groove, or over the body of the projectile in the bore. In the former case the shot lies in the bore, and is spun by its buttons; in the latter it lies and moves through the bore on its buttons, whose faces are the medium through which direction is given, while their driving edges impart rotation.

In all Woolwich guns both the direction and twist are given by the bearing of the studs on the grooves, the body of the shot never being intended to come into contact with the bore, so that, in fact, the action of the latter is merely to confine the gas and keep it behind the projectile, which is made with a windage of $\cdot 08''$ in all calibres. Action of studs.

From this it follows that the exact forms of groove and stud become of great importance and deserve particular notice. The cross section of a groove shows the depth, viz., $\cdot 18$ to $\cdot 2$ inches in the middle, and also the curve of the bottom, which is not concentric with that of the bore, but struck with a radius of three inches from a centre taken on that radius of the bore which bisects the groove; the full breadth of the latter is $1\cdot 5$ inches, the edges being arcs of circles of from $\cdot 25$ to $\cdot 3$ inches radius. The projectiles have two studs for each groove in all instances; both studs in the case of a uniform twist and the rear one where the twist is increasing are of the following dimensions:—Total breadth, $1\cdot 42$ inches, shoulders formed like those of the groove with an arc of a circle from $\cdot 25$ to $\cdot 3$ inches according to the calibre, the centre projecting $\cdot 195''$ beyond the body of the projectile; the face of the stud in more recent patterns corresponds to the curved bottom of the groove,² that is, its cross section gives an arc of a circle of three inches radius. Form of grooves and stud.

Next as to the play. This is seen most readily in a case where the number of grooves is even, and stud is consequently opposite to stud. Taking as an example the 9-inch, the total diameter of the projectile over the studs is $9\cdot 31$ inches, while that of the gun across the grooves is $9\cdot 36$ inches, giving a windage over studs of $\cdot 05$ inches, the difference of breadth of groove and stud being $\cdot 08$ inches. With regard to all these details it is sufficient to notice that, the groove face being part of a small circle, when the stud is moved to one side of the groove, instead of being kept opposite to the middle, it bears on a surface that Centering principle.

¹ Captain Haig submitted a spiral whose development is given by the equation $y = \frac{2ax^{\frac{3}{2}}}{3\sqrt{l}}$ where x is measured in the direction of the bore from the commencement of the rifling, and y perpendicular to it, $a = \tan$ (angle of rifling at muzzle), l = the distance from commencement of rifling to muzzle, or total length of rifling. The object of this was to obtain approximately uniform pressure between the studs and grooves throughout the bore, by a form of rifling intermediate between the uniform and uniformly gaining twists.—*Vide Ordnance Select Committee*, extracts, vol. iii., p. 179, except a misprint of $\frac{3}{2}$ instead of $\frac{3}{4}$.

² The form of the studs at the upper surface is made to coincide with the grooves in the gun instead of being concentric with the projectile. *Vide Changes in War Stores*, New Series, § 1518, 21/10/67.

is nearer to the centre of the bore, and in theory it is lifted and made to centre itself on an axis more nearly approximate to that of the piece, but in practice, the studs being gun metal, and the curve closing inwards very little in so short an arc, the effect can hardly differ appreciably from that which would be given by grooves whose surfaces were concentric to that of the bore, still the centering principle¹ should be noticed, because it seems to be the object with which this form has been designed, and it may be observed that by the time the projectile reaches the muzzle of the gun, considerable wear has taken place on the driving edges of the studs, and here any centering action would have its maximum effect.²

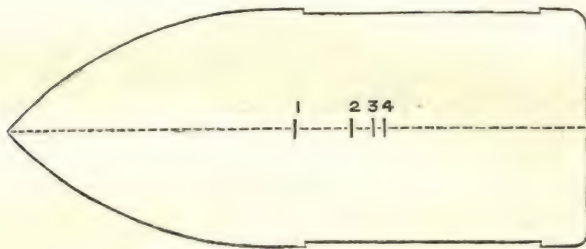
As to the number of studs, two to each groove seem to be necessary to carry out the above principles, and the fact that surprisingly good results have been obtained with only one, simply shows how little practically depends on the centering principle, and on the decrease of $\cdot 03$ inches of windage, where gun-metal bearings perform such sudden and violent work; for a shot with a single stud which is not opposite its centre of gravity must lie partly on the rear stud in the groove, and partly on the front portion of the body in the bore, the rear portion having $\cdot 05$ " windage and a gun-metal bearing on iron, and the front $\cdot 08$ " windage and iron bearings. This then is its condition of rest, but when it commences to move the forces become complicated with shot of the service form, for the metal in the ogival head is placed so as to tell more on the balance of the shot, that is on the position of its centre of gravity than a similar quantity of metal in the base, while being placed nearer the axis of the piece it gives less resistance to rotation, hence the part where any force applied to spin the shot, would meet with equal resistance on each side of it would not be opposite to the centre of gravity.

In point of fact, four centres may be taken in the longer axis of a projectile on different principles:—

1st. A point bisecting the longer axis, commonly called the centre of the figure.

2nd. The centre of gravity on which the shot would balance.

3rd. Such a point, that a plane section passing through it at right angles to the longer axis would divide the metal into equal volumes or weights.



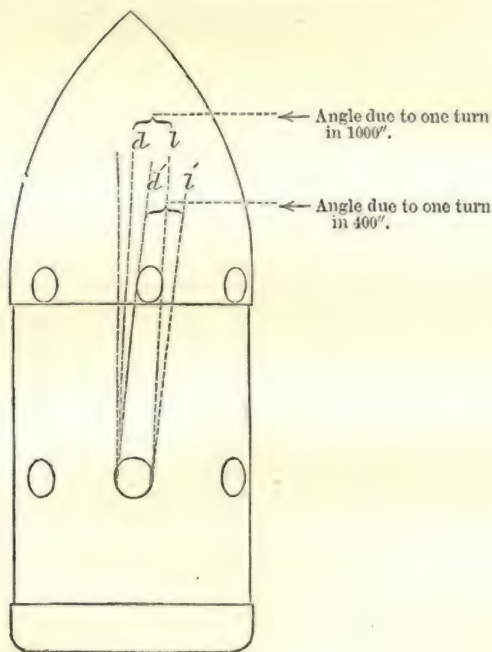
¹ Commander Scott's rifling was based on this principle. "The surface of the ribs on the shot and the bottom of the grooves in the gun are struck with the same radius, by which, in combination with the curves which he has chosen for the driving side, Commander Scott hopes to obtain a perfect centering for his shot." *Vide Ordnance Select Committee Extracts*, vol. ii., p. 290.

²The Committee on Field Ordnance for India report that recovered projectiles fired from an experimental Woolwich gun showed clear evidence of non-centering, *vide report*, p. xii.

4th. Such a point, that a plane section passing through it at right angles to the longer axis divides the projectile so that the "work done" in giving rotation is the same on each portion.

These points will probably be found in the above order, reading from point to base in service projectiles, and unless the base be made symmetrical with the head, they can never all coincide.

It has been said that practically projectiles shoot well with one ring of studs only, but a small number of rounds as yet have been fired, and it remains to be seen whether the bore suffers from this treatment. The advantage of firing projectiles with a single ring of studs would be great in some cases, for the projectile would be available for any pitch of groove. The front studs in all the service projectiles project the same amount as the rear ones, so as to keep the axis of the projectile parallel to, although as has been noticed not mathematically coincident with, that of the bore, then as to rotation with a uniform twist the front studs exactly resemble the rear ones, and both together drive the shot throughout its passage up the bore, but with the increasing spiral this is impossible,¹ Front studs with increasing twist. for the groove runs nearly longitudinally along the projectile at the bottom of the bore while it crosses it at almost the angle due to the full rate of rotation before the front studs clear the grooves at the muzzle, hence it follows that there is only a very much narrowed strip of the projectile that comes opposite to the groove in both its extreme positions, which are roughly shown in the annexed figure. The rear stud being of the



¹ In the French system of increasing twist, the front stud was the full size and the rear one reduced, but this appears inferior to the opposite arrangement for more than one reason.

dimensions given above, it will be seen that the shaded space is the only part that remains opposite to the groove in all positions, and the front stud is therefore necessarily limited in its breadth to enable the shot to pass down the bore; for to enter the grooves $d' l'$ at the muzzle the front stud must not extend to the left of the edge d' , while to admit of being rammed home it must not extend to the right of the edge l . The exact breadth will of course vary with the circumstances of each case, and cannot therefore be laid down here.

Thus the front stud touches the driving edge d' , on entering the bore, and the loading edge l , when well home; and the reverse action occurring in firing the share it takes in the work of rotation is very small, for until the driving edge meets it, the whole pressure is on the rear stud, indeed it is only owing to the wear of the latter that the former comes in contact with the driving edge of the groove before it reaches the muzzle, and it has even been doubted whether it actually does so, but an inspection of the front stud¹ of recovered shot bears out the statement that a certain part of the work of rotation falls on it although the chief use appears to be to steady the projectile.²

Longitudinal
position of
studs.

The longitudinal position of the studs has now been fixed as follows:—The centre of the rear stud is to be not less than four inches from the base of all projectiles.³

The front and rear studs are to be at equal distances in front and rear of the centre of gravity of the projectile, except in the case of Palliser cored shot, and are to be the same distance apart on all projectiles for the same gun.⁴

The rear stud has been moved forward to suit the navy,⁵ who use a canvas bearer in loading, which does not bring the projectile up to the muzzle of the gun (like the land service bearer), with its studs opposite the grooves, but in an accidental position; it is therefore convenient to rest that part of the base which is clear of studs in the bore, and thus

¹ The superintendent (Shoeburyness) remarks that "on examination of the shells after being recovered, the front stud was found in every instance to have been worn away on the driving side, showing that it had come into bearing." The same effect was seen even when the front stud was "very much reduced in size." Vide *Ordnance Select Committee Extracts*, vol. iii., p. 156, 5/6/65 and 7/6/65.

² On experiment with front studs still further reduced in size. "On this occasion the reduction in the size of the front studs was effectual, those on the recovered shell showing no symptoms of having touched the driving side of the groove. The practice is very nearly as good as that reported in June, and inclines the Committee to the conclusion that the use of those studs is to steady the shot in the bore and not to rotate them." Vide *Ordnance Select Committee Extracts*, vol. iii., p. 256, 24/7/65.

³ Fixed by a letter from Ordnance Select Committee to Superintendent Royal Laboratory, dated 12/9/67.

⁴ In all the projectiles of the same calibre, the front and rear stud shall be placed (as far as practicable) at one uniform distance from each other. Changes in War Stores (new series) § 1518, 21/10/67, 74/12/33-40.

⁵ A letter from Capt. Hood, R.N., H.M.S. "Excellent," 21/3/67, forwarded to the Ordnance Select Committee, says "that the bearing actually necessary to sustain the weight of the shell in the muzzle when lodged for the purpose of turning it for the entry of the studs into the grooves is, in the case of the 7-inch gun, 1' 5", and in that of the 9-inch 1' 75". He therefore considers "that these distances are the least that can be allowed from bottom of projectile to studs."—*Ordnance Select Committee, Min.* 21, 430, subject No. 2424 (*Ordnance Select Committee proceedings*).

relieved of the weight of the projectile, to turn it round until its studs come into proper position.¹

The question arises of how this advanced position of the rear stud affects the shooting; this has of course been tested, and it has been found by practice that no harm results from it, indeed, as to direction, it stands to reason that the large stud in rear should be as near if not nearer to the centre of gravity than the front one, while as to rotation with the increasing twist it seems still a question whether the rear studs which performs the main part of this work would not still better effect this purpose if placed much more nearly opposite to the centre of gravity (*vide* page 58).

Placing the studs at a ² uniform distance apart on all projectiles of the same calibre simplifies gauging, which otherwise becomes complicated in the case of an increasing twist. This plan entails one gauge only to test the edges of the studs of each calibre (*vide* p. 103).

Gun-metal studs (so called) were formerly made of a hard alloy³; they were screwed into the projectiles which had holes tapped to receive them, except in the case of Palliser projectiles, which, being formed of iron too hard to tap, were cast with undercut holes into which the studs were driven, these latter being made of a soft alloy.³ Owing however to bad shooting made with Palliser shot, which it was thought might be due to the softness of studs, but which probably arose from the short length of the solid shot, an experiment³ was made to test the comparative accuracy of projectiles with hard and soft studs, on which occasion the latter shot quite as well as the former, indeed from some accidental cause they shot a little better.

Material and method of attaching studs.

Further attention being given to this matter the Superintendent of the Royal Laboratory⁴ finally recommended studs for Woolwich rifled projectiles of an alloy of seven parts copper to one of tin,⁵ which is sufficiently soft to enable the stud to be attached to the projectile by pressing it into undercut holes in the latter, causing the end which is cupped or hollowed out to expand and rivet itself firmly in,⁶ *vide* fig. page 69. A softer alloy (10 parts copper to 1 tin) is now used for 7" projectiles, and may come in for larger calibres.

Studs so attached may be recognised at once by the absence of the square wrench hole which characterizes the larger studs which are screwed in; the front screwed in studs of projectiles for the increasing twist do not exhibit this difference, having been turned round by means of a square neck, which was eventually twisted off.

¹ It has been thought advantageous to lift the shot and enter its base in the bore and turn it to its required position, in preference to hooking the shot bearer on the muzzle, in serving these guns on land as well as on board ship.

² As nearly as possible equidistant from centre of gravity, and at the same distance from one another in the same calibre so as to allow one gauge to be used for all. See Report (Ordnance Select Committee Proceedings), 4666, Minute 22/679, date 30/7/67. See also *Changes of War Stores*, § 1518.

³ Twenty 7-inch solid shot were cast in sand, 10 had hard gun-metal studs screwed in (*viz.*, 89'44 parts copper, 9'94 tin, and '62 zinc, and 10 soft metal, *viz.*, 86'96 parts copper, 3'62 tin, 5'80 zinc, and 3'62 lead), similar to those of the Palliser shot staved into undercut holes. The mean deviation of the latter was rather less than that of the former. *Vide* Ordnance Select Committee Proceedings, Min. 19, 911, and Ordnance Select Committee Extracts, vol. iv., p. 389.

⁴ *Vide* Ordnance Select Committee Extracts, vol. v., p. 153.

⁵ A softer alloy however is used for studs of certain 7" projectiles, *vide* p. 65.

⁶ This is effected by the action of an eccentric of a machine devised by Mr. Davidson, Manager, Royal Laboratory.

Length.

Length of
projectiles.

This necessarily varies in the different descriptions of projectiles for the same gun, inasmuch as it is to some extent subordinate to the consideration of bringing them all (with certain exceptions) to the same weight, but it has been decided that a length of two calibres¹ at least is necessary for very accurate shooting, and it is desirable for good "vis viva" or destructive effect on impact at any but very short ranges to have the weight great in proportion to the calibre, or in fact to the surface of resistance, and of course this is favoured by an increased length of projectile.

The question of hollow shot in place of solid connects itself with this, indeed a solid shot of two calibres long would in some cases exceed the desired weight for each gun, but besides the consideration of external form, the hollow shot having its weight distributed further from its axis has a slight advantage in having a longer radius of gyration and greater power of keeping up its rotation though entailing a slightly increased strain on the gun. It will be seen however that this question only arises with reference to Palliser shot, case being the only other description of shot for Woolwich guns.

Form of head.

The form of head is governed by two considerations, flight and penetration, and this latter, which gives different² forms in different instances, will be discussed in detail. The question of flight affects all equally, and on this experiments³ have been made which resulted in the adoption

¹ Capt. (now Admiral) Key, of H.M.S. "Excellent," in a letter, says, "He has fired both shell and shot from a 64-pr. muzzle-loading gun without detecting any difference between them as to accuracy or range; the short solid shot were very inferior to both." Vide *Ordnance Select Committee Extracts*, vol. iii., p. 35.

"He (Professor Bashforth) desires to call the Committee's attention to the superior accuracy of shell over shot in the trials with guns of various degrees of twist, from which it appears that the increased length of projectile tended to increased steadiness." (*Ordnance Select Committee Extracts*, vol. iii., p. 70.)

"Experience has led the Committee to conclude that to attain very accurate shooting the projectiles of M.L. guns must not be less than two calibres in length. It has been observed that the shooting of common shell is almost invariably better than that of segment shell or common shot. This difference is attributed partly to their length and partly to the favourable conditions of the hollow form, by which the centre of gyration is thrown further from the axis of the projectile. The one condition points to elongating the shot, and the other to making it hollow, and inasmuch as cast-iron hollow shot of moderate thickness are strong enough for all battering purposes for which cast-iron projectiles are likely to be used, while they have the further advantage of being easily convertible into battering shells, the Committee propose the introduction of hollow instead of solid shot, and to make these shot of such weight as will give a length favourable to accurate shooting. This weight will also give a greater vis viva at a given distance than a lighter and consequently a shorter shot fired with a larger charge. There will therefore be economy in the stowage and quantity of gunpowder, combined with increased efficiency, in a system based on the foregoing principle (vide *Ordnance Select Committee Extracts*, vol. iii., p. 128).

"Recent experience has led the Committee to conclude that to attain very accurate shooting the projectiles of muzzle-loading rifle guns must not be less than about two calibres in length, and inasmuch as a solid shot of a weight consistent with the safety of the gun will not fulfil this condition, it became necessary to look for a more favourable form." Vide *Ordnance Select Committee Extracts*, vol. iii., p. 128.

² A letter from the Ordnance Select Committee, 13/11/65, to the Superintendent, Royal Laboratory, gives forms for the heads of shells and shot for Woolwich guns nearly approaching those now in the service.

³ Of the forms tested as to the resistance they meet with in flight, viz., No. 1 nearly parabolical (service form), No. 2, hemispherical, No. 3, parabolical, focus $\frac{1}{10}$ diameter; 4, equilateral cone; 5, ogival, radius two diameters. The Ordnance Select Committee report "that the conoidal or ogival form is superior to either of the above, and the fronts of any new shot introduced into the service should approximate to "this form as nearly as is compatible with suitability for the service in other respects." (*Vide Ordnance Select Committee Extracts*, vol. ii., p. 305.)

of what is termed an ogival head struck with a radius of 1.5 diameters for common shell of all calibres.^{1, 2}

¹ The construction of ogival heads of radii of 1, $1\frac{1}{4}$, and $1\frac{1}{2}$ diameters respectively may be seen in the figs. 1, 2, and 3 below.

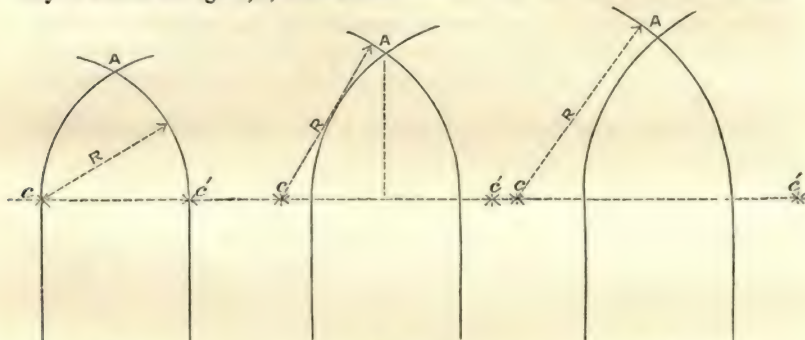


Fig. 1.

Fig. 2.

Fig. 3.

C and C' being the centres, and R the length, of the radii, in each case.

It may be observed in the case of $1\frac{1}{4}$ diameters radius (fig. 2) that the head is exactly 1 calibre long—

$$\begin{aligned} \text{For } (CA)^2 &= (CB)^2 + (BA)^2 \\ \text{i.e. } (BA)^2 &= (CA)^2 - (CB)^2. \end{aligned}$$

or, in terms of the diameter or calibre—

$$\begin{aligned} D^2 &= \frac{25}{16} D^2 - \frac{9}{16} D^2 \\ &= \frac{16}{16} D^2 \\ &= D^2 \\ \text{or, } BA &= D \end{aligned}$$

that is, BA the length of the head = 1 calibre.

² Having found the volumes of the service forms of ogival heads by integration, and the results having been worked on with slight modification in the Department, I give them on the possibility of their being required, when much calculation will be saved by adopting them.

Taking D as the diameter of the shot, the volumes of the solid heads are as follows :—

With an ogival head of 1 diameter radius—

$$\text{the vol. of the head} = D^3 \times .395592 - \quad \text{I.}$$

with an ogival of $1\frac{1}{4}$ diameters—

$$\text{the vol. of head} = D^3 \times .44765 - \quad \text{II.}$$

and with an ogival of $1\frac{1}{2}$ diameters—

$$\text{the vol. of head} = D^3 \times .49425 - \quad \text{III.}$$

In the Laboratory drawing office for some reason that I cannot explain the decimal II. was altered to .4478, and III. to .4944, which were thought to give better results, but appear to be less correct mathematically. Col. Maxwell has also worked out these heads and obtained the same decimals as myself.

The calculations to obtain the above are of course tedious, the equations, integrals, and general results are as follows, taking the origin in the axis of the head :—

For I. Where R (the describing radius) = D.

$$R^2 = x + \left(y + \frac{D}{2}\right)^2$$

$$\begin{aligned} \text{and vol.} &= \pi \int_0^{D \sin 60} \left(D^2 - x^2 - D\sqrt{D^2 - x^2} + \frac{D^2}{4} \right) dx \\ &= \pi \left\{ D^2 x - \frac{x^3}{3} - D \left(\frac{x}{2} \sqrt{D^2 - x^2} + \frac{D^2}{2} \sin^{-1} \frac{x}{D} \right) + \frac{D^2}{4} x. \right\} \end{aligned}$$

Form of base.

To facilitate loading at sea with the canvas bearer noticed above, the bottoms of the more recent patterns¹ of all projectiles, case excepted, are rounded; all, except shrapnel, with a circle of 1 inch radius, shrapnel vary in this respect, as noticed in details hereafter given.

Before dealing individually with each projectile, it may be well to observe such distinctive features as necessarily spring from the rifling of the gun, and are therefore common to all the projectiles taking the grooves of each gun, in other words, all except case shot; it will be sufficient to notice these once for all, and will save vexatious repetition.

The characteristics then of each gun to which their relative projectiles necessarily correspond are as follows:—

Woolwich.

WOOLWICH.

13" gun. 10 grooves; twist; uniform 1 in 55 calibres.

12" gun. 9 grooves; twist; increasing from 1 in 100 to 1 in 50 calibres.

For II.

Where $R = \frac{5}{4}D$

$$R^2 = x^2 + \left(y + \frac{3D}{4}\right)^2$$

$$\begin{aligned} \text{and vol.} &= \pi \int_0^D \left(\frac{25}{16} D^2 - x^2 - \frac{3}{2} D \sqrt{\frac{25}{16} D^2 - x^2} + \frac{9}{16} D^2 \right) dx \\ &= \pi \left\{ \frac{25}{16} D^2 x - \frac{x^3}{3} - \frac{3}{2} D \left(\frac{x}{2} \sqrt{\frac{25}{16} D^2 - x^2} \right. \right. \\ &\quad \left. \left. + \frac{25}{32} D^2 \sin^{-1} \frac{4}{5} \frac{x}{D} \right) + \frac{9}{16} D^2 x \right\}. \end{aligned}$$

For III.

Where $R = \frac{3D}{2}$

$$R^2 = (y + D)^2 + x^2$$

$$\begin{aligned} \text{and vol.} &= \pi \int_0^{\sqrt{\frac{5}{2}} D} \left(\frac{9}{4} D^2 - x^2 - 2D \sqrt{\frac{9}{4} D^2 - x^2} + \frac{9}{8} D^2 \sin^{-1} \frac{2x}{3D} \right) dx \\ &= \pi \left\{ \frac{9}{4} D^2 x - \frac{x^3}{3} - 2D \left(\frac{x}{2} \sqrt{\frac{9}{4} D^2 - x^2} + \frac{9}{8} D^2 \sin^{-1} \frac{2x}{3D} \right) + D^2 x \right\}. \end{aligned}$$

The above are good for their own form of head. Professor Bashforth, however, has furnished me with a general formula applicable to all ogival heads.

$$R^2 = (x - a)^2 + (y - b)^2.$$

$$\text{vol.} = \pi \int_0^{\sqrt{R^2 - b^2}} (\sqrt{R^2 - b^2} - b) dx$$

$$\text{vol.} = \pi \left\{ R^2 x - \frac{x^3}{3} - b \left(x \sqrt{R^2 - x^2} + R^2 \sin^{-1} \frac{x}{R} \right) + b^2 x \right\}.$$

It will be seen, taking the origin as before, that $a = 0$, and further that $b = R - \frac{D}{2}$ in all cases.

If the value of R and consequently of b be taken according to the conditions of any of the above three cases, this general expression will become the particular equation given above.

¹ This has not been carried out with 13-inch calibre, which is nearly extinct. *Vide* Changes in War Stores, §§ 1765 and 1599.

10" gun. 7 grooves; twist; increasing from 1 in 100 to 1 in 40 calibres at muzzle.

9" gun. 6 grooves; twist; increasing from 0 to 1 in 45 calibres at muzzle.

8" gun. 4 grooves; twist; increasing from 0 to 1 in 40 calibres at muzzle.

7" gun. 3 grooves; twist; uniform 1 in 35 calibres.

The 13" gun being a converted shunt gun is confined to its original twist, the form of the groove having been altered, but not its position.¹

The 7" gun has a uniform twist, because the Admiralty at the time of its introduction preferred the uniform to the increasing spiral.^{2, 3}

The following properties are common to the projectiles of each calibre, and may be assumed where the reverse is not stated, and as they vary with the calibre it would cause confusing and vexatious interruptions to introduce them all under the head of each description of projectile:—

1st. The weights to which all the projectiles of each calibre (except case shot and double shell) approximate as nearly as possible are as follows:—

For 13" gun 600 lbs.

„ 12" „ 600 „

„ 10" „ 400 „

„ 9" „ 250 „

„ 8" „ 180 „

„ 7" „ 115 „

With the 12" gun there is a very serious departure from this system in the case of the common and shrapnel shells, but of this more hereafter.

The constant distance between the front and rear stud adopted for all the projectiles of each calibre in the more recent patterns, as mentioned at pages 60, 61, is as follows:—

For the 12" it is 7"

„ 10" „ 8"

„ 9" „ 6"

„ 8" „ 5"

„ 7" „ 4".6

All Woolwich projectiles, except those of the 7-inch calibre, now have studs of an alloy of seven parts copper to one of tin swedged into undercut holes; 7-inch projectiles have a softer alloy, viz., 10 parts copper to one of tin. For alloys used in studs screwed into projectiles, and the soft studs originally swedged into Palliser shot and shell *vide* page 61.

The projectiles now in the service for Woolwich guns are as follows:—

- a. Shell (viz., common, double, Boxer, shrapnel, and Palliser's).
- b. Shot (viz., Palliser's and case).

¹ *Vide* letter from Superintendent Royal Gun Factories, 17/11/65. *Ordnance Select Committee Extracts*, vol. iii., p. 326, giving pitch 1 turn in 55 calibres, 10 grooves, &c.

Also "the Woolwich form of groove is free from the defect due to sharp angles, and as the grooves of the two remaining 13" guns can easily be altered to that form the Committee recommend that instructions be given to the Superintendent Royal Gun Factories to alter them accordingly."

² *Vide Ordnance Select Committee Extracts*, vol. v., p. 99.

³ „ „ „ vol. iii., p. 227, Minute 16/625.

N.B.—Besides these, steel shot and shell (Alderson's), although obsolete, might possibly be met with.¹

Shell.

a. SHELL.

1. Common.
2. Double.
3. Boxer shrapnel.
4. Palliser's.

1. *Common Shell.* (Calibres, 13", 12", 10", 9", 8", and 7".)

Common shell.
Calibres.

Shells, rifled,
M.L. common,
13, 12, 10, 9, 8,
and 7 inch.

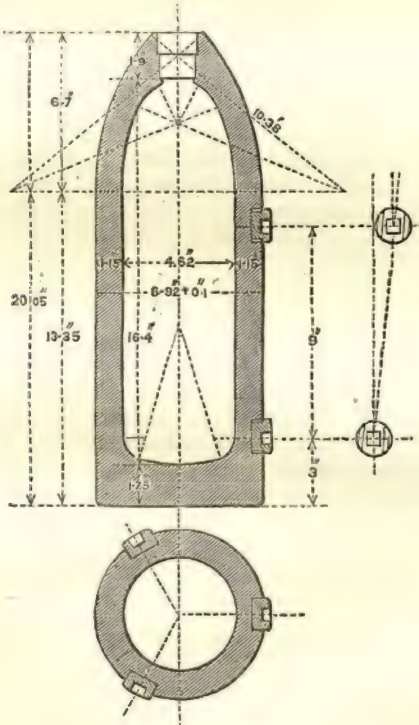
The general form is about 3 calibres in length, with ogival head, $1\frac{1}{2}$ diameters radius; the 12" and 13" however are shorter than the above, the 13" being only 29"·5, and the 12" only 30" long.

All are lacquered internally with red lacquer. (Composition, *vide* page 12, note ³.)

All, except the two first patterns of 7" and 9" shells, have two extractor holes in their heads.

The fuze hole gauge is in every case the general service, countersunk ·2" in all but a few earlier patterns, in which it was ·1", and bushed, taking Boxer 9 or 20 seconds M.L.O. or Pettman G.S. percussion fuze as service fuzes.

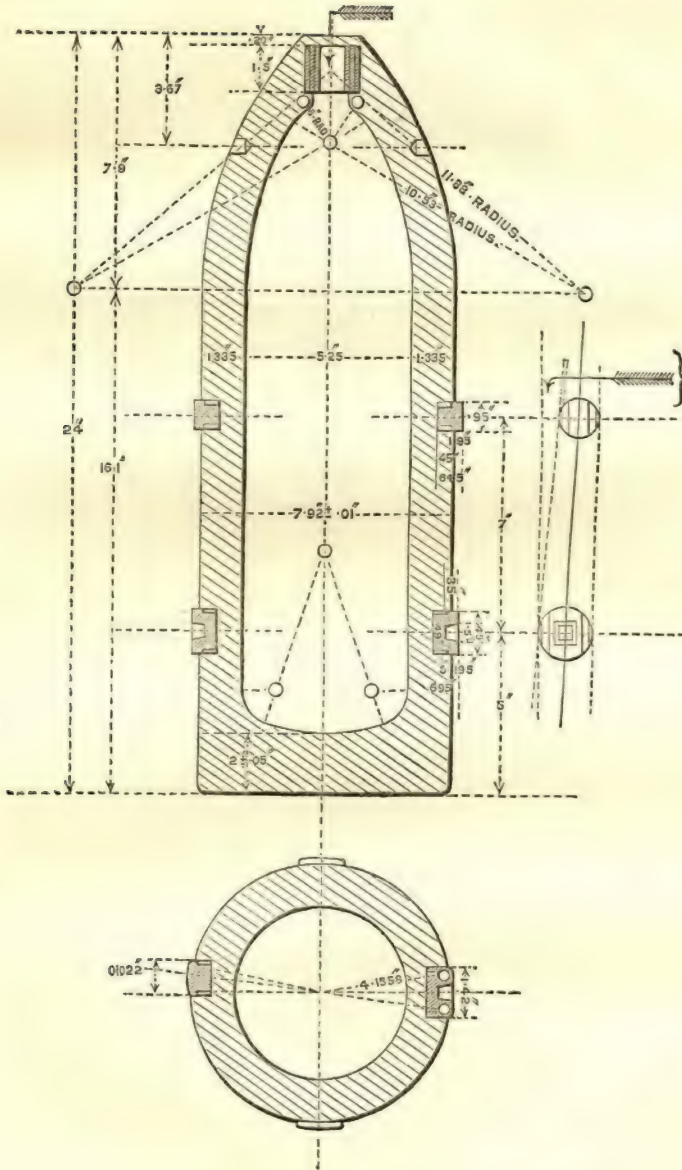
All shells made since 23/3/69 have unloading holes² (*vide* details of patterns).



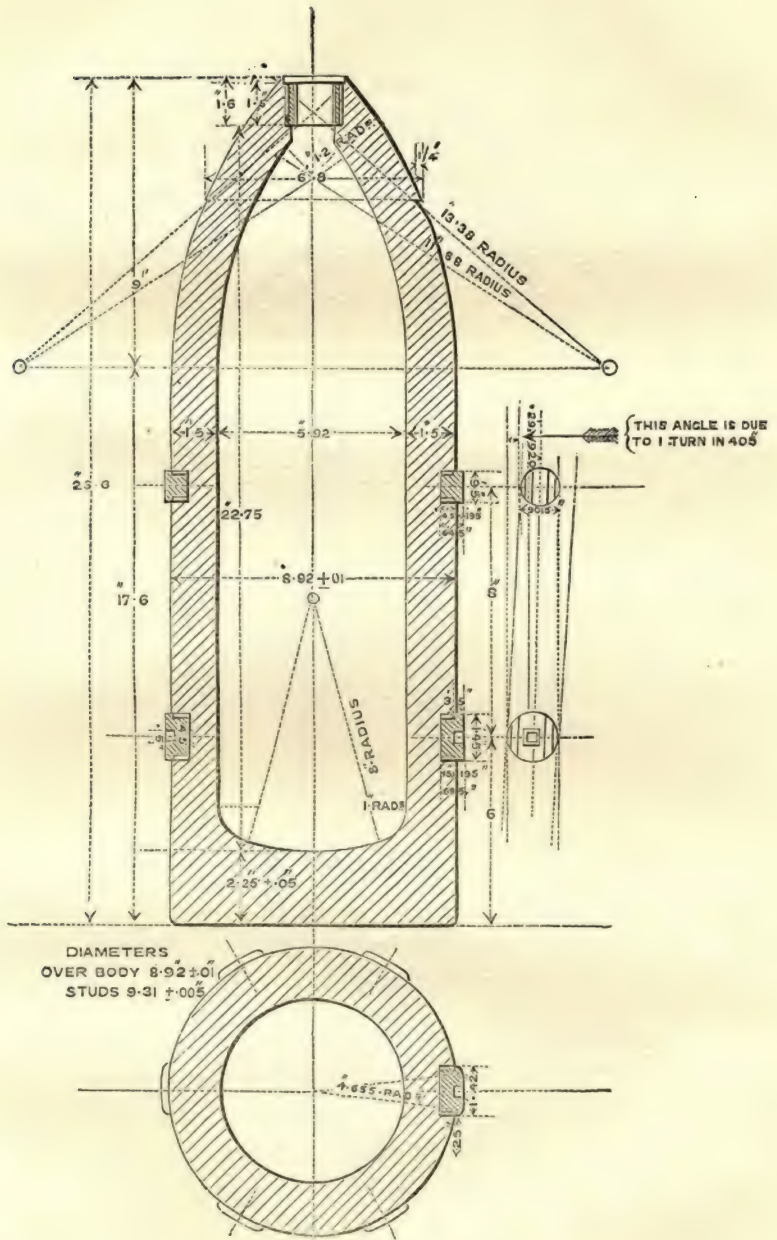
COMMON SHELL, 7", I.

¹ *Vide* Changes in War Stores, §§ 1297, 1118, and 1043. Steel shot and shell had heads painted white, that of the shell had a red tip, the head was unscrewed to enter the bursting charge. Steel heads latterly were stamped S.

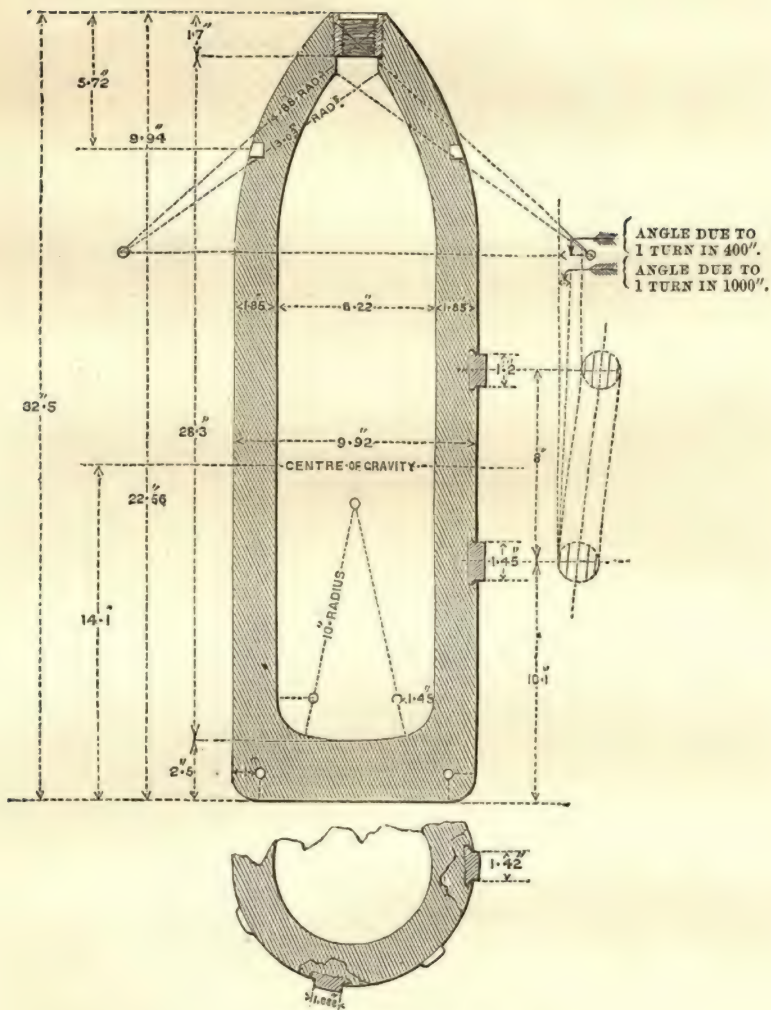
² *Vide* Changes in War Stores, § 1764.



COMMON SHELL, 8", I.

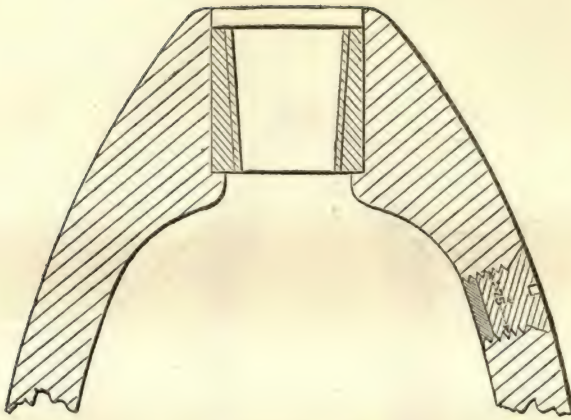


COMMON SHELL, 9", II.

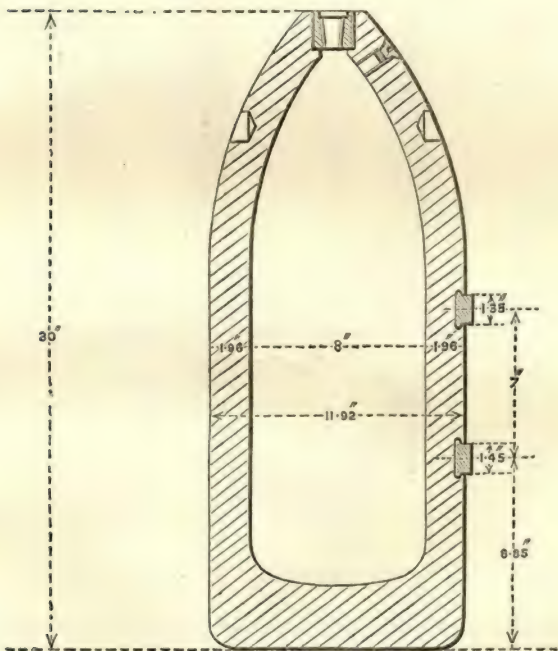


COMMON SHELL, 10", I.

(N.B.—The sides or walls may perhaps be thickened in future patterns.)



UNLOADING HOLE.



COMMON SHELL, 12'', I.

The details of patterns may be seen in the following table (p. 71):—

COMMON SHELL.

Patterns.	Date of Approval.	Changes in War Stores.	Length.	Weight Empty.	Approximate bursting Charge of Shell Powder L.G.	Weight of filled Shells, &c., in lbs. (Limits of error $\pm \frac{1}{2}$ per cent.	Countersink of Bush.	Studs screwed in or staved into Under-cut Holes.	Distance between centres of Front and Rear Studs.	Edge of Bottom rounded.	Unloading Hole.	Marks in Front of One Front Stud.	Marks on Rear Studs for the same Groove as the marked Front Stud. The Date refers to the Manufacture of each Individual Shell.	Remarks and Improvements on previous Patterns.
13" Mark I. - -	Provs only. 21/9/07	-	ins. 29.5	lbs. ozs. 567 7	lbs. ozs. 32 9	lbs. 600	ins. .2	Swedged	ins. 12	No	No	R \uparrow L	Date and \times	Only sealed by Ordnance Select Committee. The small bursting charge is due to the great thickness of this shell.
12" Mark I. - -	20/3/09	\$1766	30	460 0	35 0	495	.2	Swedged	7	Yes	Yes	R \uparrow L	Date and \times	
10" Mark I. - -	18/9/08	\$1678 and 1707.	32.5	373 12	26 4	400	.2	Swedged	8	Yes	Yes	R \uparrow L	Date and \times	
9" Mark I. - - Afterwards altered to Mark II.	19/5/06	\$1239	26.6	232 0	18 0	250	.1	Screwed	8	No	No	R \uparrow L	Nil -	A groove runs round the head for teeth of O. P. extractor.
9" Mark III. - -	26/11/06	\$1337	26.6	232 0	18 0	250	.2	Screwed	8	No	No	R \uparrow L	Nil -	Two extractor holes for N.P. extractor and countersink of .2".
9" Mark IV. - -	21/10/07	\$1518	26.6	232 0	18 0	250	.2	Swedged	6	No	No	R \uparrow L	Date and \times	Studs swedged in and placed at a constant distance apart.
9" Mark V. - -	9/12/08	\$1765	26.75	232 0	18 0	250	.2	Swedged	6	Yes	Yes	R \uparrow L	Date and \times	Rounded edge at base and unloading hole.
8" Mark I. - -	15/10/06	\$1338	24	167 0	13 0	180	.2	Screwed	7	No	No	R \uparrow L	Nil.	Studs swedged in and placed at a constant distance apart.
8" Mark II. - -	21/10/07	\$1518	24	167 0	13 0	180	.2	Swedged	5	No	No	R \uparrow L	Date and \times	
8" Mark III. - -	9/12/08	\$1765	24.17	167 0	13 0	180	.2	Swedged	5	Yes	Yes	R \uparrow L	Date and \times	
7" Mark I. - -	18/1/06	\$1188	20.05	106 12	8 4	115	Not finished.	Screwed	9	No	No	R \uparrow L	Nil -	It has three extractor holes. Alloy of studs, copper 9 lbs., tin 1 lb., zinc 1 oz., this shell is not bushed.
7" Mark II. - -	19/5/06	\$1240	20.05	106 12	8 4	115	.1	Screwed	9	No	No	R \uparrow L	Nil -	Three extractor holes.
7" Mark III. - -	26/10/06	\$1341	20.05	106 12	8 4	115	.2	Screwed	9	No	No	R \uparrow L	Nil -	Two extractor holes and countersink, .2".
7" Mark IV. - -	21/10/07	\$1518	20.1	106 12	8 4	115	.2	Swedged	4.6	No	No	R \uparrow L	Date and \times	Studs swedged in and placed at the constant distance of 4.6".
7" Mark V. - -	9/12/08	\$1765	20.4	106 12	8 4	115	.2	Swedged	4.6	Yes	Yes	R \uparrow L	Date and \times	Edge of bottom rounded, and unloading hole added.

N.B.— \times indicates that the face of the stud is made to correspond with the curve of the groove, *vide* page 57, note 2.

COMMON SHELL.

Paint. Common shell are painted black all over, except the studs and screw plug (the unloading hole plug not being excepted).

Issue.

Issue. Common shells are issued.

Filled. 1st. Filled for S.S., fuze with Pettman's G.S. percussion fuze, and mark "filled" in red letters, being placed in¹ jute bags for transit, and the word "filled" being marked in red, besides the nature and calibre of the projectiles and description of fuze.

²All issued since April 11th, 1870, have the date and R \wedge L, also W marked in red.

Empty, S.S. 2nd. Empty for S.S., with screw plug, G.S. gauge, and blue waxed wad over it, these are also placed in jute bags for transit.

Empty, L.S. 3rd. Empty for L.S.,³ with screw plug, G.S. gauge, placed in jute bags for transit.

USE.

Use and experience. The main point to notice is the great explosive power of these shells.

They are intended generally to be used with percussion fuzes for sea service, but inasmuch as such fuzes are constructed not to explode against water, even at a high velocity, they are not at all certain to act on graze on land, hence for land fronts no percussion fuzes are supplied, the M.L.O. wood fuzes explode on direct impact by being split or driven into the shell. All the shells are filled completely with "shell powder, L.G."

EXPERIENCE WITH M.L. COMMON SHELL.

There have been instances recorded of 64-pr. shunt shells having over-ridden their grooves, but none of the shells of Woolwich guns having done so. The bore of the shunt gun may even be cut by a copper stud; it may appear strange for the soft copper to cut the comparatively hard steel, but this only occurs after the former has become greatly compressed, and obviously if copper were wedged in and pressed between steel surfaces, the work would require greater and greater force as the copper became denser and denser, and eventually would exceed the crushing strength of the steel, so that the latter would give way. It appears then, that these conditions may be fulfilled when studs over-ride their grooves in the 64-pr. shunt gun.

The experience connected with the common shells of Woolwich guns has been very satisfactory, unless an exception be made with reference to the unfortunate introduction of the 12-inch gun with such a twist as rendered it necessary to discard its two longest projectiles, viz., its common and shrapnel shells, constructed at first to weigh about 600 lbs., on the score of bad shooting, for two shorter and much less powerful ones, weighing only about 495 and 496 lbs. respectively.

¹ *Vide* Changes in War Stores, §§ 1588 and 1517.

² Changes in War Stores, § 1880, directs that in addition to the word "filled" ordered by § 1349, the date and initial letter or monogram of the station where they are filled are to be stencilled on the shells in red paint.

Shells filled on board ship to have the word "filled" and the date in white paint.

³ A few common shells have recently been issued filled for L.S.; they had the screw plug in the fuze hole, but not the mill board wad used in shells carried filled in limbers.

The effect produced by the pressure on the sides of a M.L. common shell from the gas rushing past is found to be most remarkable, the shell having a tendency to assume a form approaching that of a dumb-bell. The base being solid transversely, is not appreciably compressed, but the end of the body close to the commencement of the head, although receiving considerable support from the latter, is acted on to some extent, while the body about the middle, where it is weakest, is forced inwards, and decreased in diameter to an extent which would hardly be credited.¹

No experiments have been made as to the explosive effects of the largest descriptions of common shell, either in earthworks or in masonry; they may be assumed to be very great from their capacity and the bursting charge they contain. The only idea of their power is obtained by comparing their bursting charges with those of large smooth-bore shells as follows²:—

				lbs.	oz.
	13-inch rifled shell contains -	-	-	32	9
	12 " "	-	-	35	0
	10 " "	-	-	26	4
	9 " "	-	-	18	0
	8 " "	-	-	13	0
	7 " "	-	-	8	4
The	13-inch S.B. contains	-	-	10	0
	10 " "	-	-	5	4
	8 " "	-	-	2	9

DOUBLE SHELL, 7-INCH.

(7" only.) The double shell was introduced in 1866. It is simply a common shell prolonged to a length of 27·2", and strengthened by three internal flanges running longitudinally to give the necessary support to prevent the shell breaking up in the bore of the gun.

Like common shell it has an ogival head $1\frac{1}{2}$ diameters radius, with two extractor holes, and is cast with a solid bottom; it has the G.S. fuze hole bushed and countersunk .2", taking the 9 seconds Boxer M.L.O. fuze or the Pettman G.S. percussion fuze as its service fuzes.

There have been three patterns of this shell, all are in the Royal Laboratory pattern room, the length in each case is 27.2", the weight empty 146 $\frac{3}{4}$ lbs. (limits 1 $\frac{1}{2}$ per cent.), it contains a bursting charge of 12 $\frac{3}{4}$ lbs. of "shell powder L.G.," the total weight filled (of each pattern) being 159 $\frac{1}{2}$ lbs.

Shell, rifled, M.L. double, 7-inch. Details of pattern.

These patterns are as follows :—

1st. Approved 9/10/66,³ it has a flat bottom, the studs are screwed in, the distance between front and rear studs being 11'8". Marks R \uparrow L in front of one front stud ; the pattern is marked I. only on the label. It is recognised at once by the square key holes in the studs as well as by their position.

2nd. Approved 21/10/67,⁴ differs from the above only in having studs pressed in at the constant distance apart for 7" projectiles, viz., 4·6", the rear stud being about 9" from the base. Marks R $\overset{\text{II}}{\uparrow}$ L in front of

¹ For example, the diameter of a 9" shell has been reduced from 8.92" to 8.55" about the middle.

² *Vide* Changes in War Stores, § 1116.

§ 1339.

4 " " § 1518.

one front stud, and date of manufacture and × on corresponding rear stud.

3rd. Approved 9/12/68,¹ differs from pattern II. in having the edge of the bottom rounded, and in having an unloading hole. Marks R ^{III} L in front of a front stud, and date and × on corresponding rear stud.

It is painted black all over except the studs.

Paint.

It is issued in the following ways :—

Issue.

1st. For S.S. only filled and fuzeed with Pettman's G.S. percussion fuze, being placed in a jute bag, both shell and bag being marked "filled" in red letters, also any since 11/4/70 R [↑] L and W.

2nd. For S.S. only, empty with G.S. screw plug with blue waxed wad in recess over fuze hole plug. May be placed in a jute bag for transit.

3rd. For L.S. empty with G.S. screw plug, jute bag to be used if required.

This shell is intended to be used when firing at wooden ships at short ranges. It has never been used on active service, but tremendous effects have been obtained at experimental practice.² It is not contemplated to fire it at long ranges, as its flight would be inaccurate, owing to its great length.³ At 2,000 yards however it has given good results.

Use and experience.

BOXER SHRAPNEL SHELL FOR WOOLWICH GUNS.

(Calibres,⁴ 12, 10, 9, 8, and 7 inch).

Boxer shrapnel for Woolwich guns resemble that for the 7" B.L., *vide* p. 33, in their general features. There are however the differences due to the difference of the systems, that is, they have gun-metal studs instead of lead coats; each has two extractor holes; besides this their proportions vary slightly, and except in the case of the 7" Mark I. they contain sand shot instead of mixed metal balls.

Shell, rifled, M.L. Shrapnel Boxer, 12, 10, 9, 8, and 7 inch.

This shell has a G.S. gauge bush and takes the 9 seconds Boxer M.L.O. fuze as its service fuze.

The details of patterns may be seen in the following table, all the shell are in the Royal Laboratory Pattern Room :—

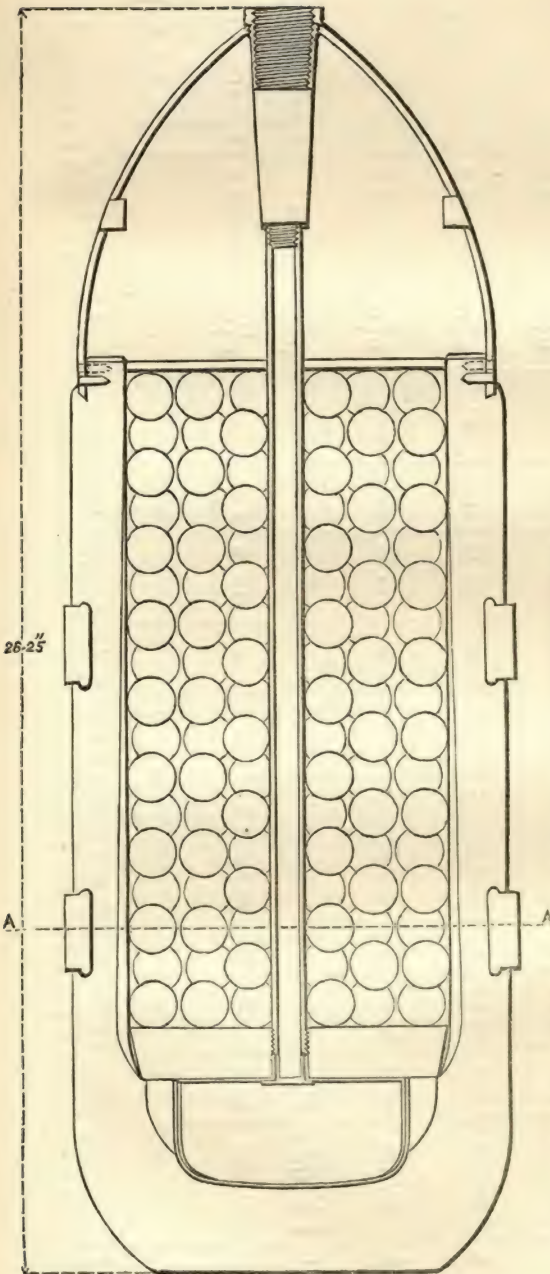
¹ *Vide* Changes in War Stores, § 1765.

² Admiral Key, R.N. reports in a letter, 22/2/66, on practice conducted against the "America" at 700 yards range; that "the destructive effect was unusually great, although in no instance did they set the ship on fire." . . . "One burst about six feet inboard on the lower deck, entirely destroying one half of a main deck beam with about eight feet square of planking, and cutting severely into the planks and a beam of the lower deck."

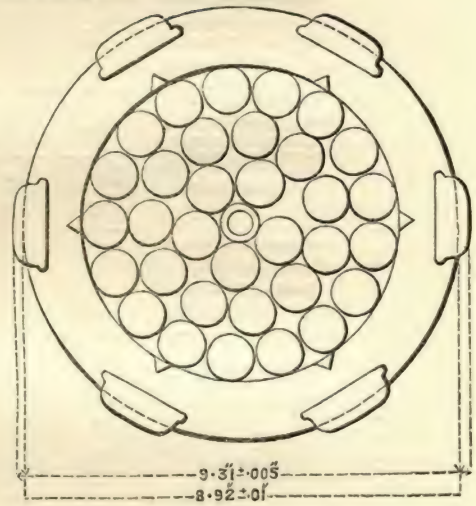
"Another struck the chain cable on starboard quarter by which the ship was slung, and burst before passing through, making a clean hole inside about 26" square, and laying eight planks on the side open to the extent of 28 feet by 8 feet; the damage in this case was very close to the water line." "These shell have been fired over 700 yards with astonishing accuracy." . . . "The real value of these shells has been more prominent in the late trials against the "America," where the effect of the large burster is so apparent." *Vide Ordnance Select Committee, Minute 18292, 12/3/66, p. 28, vol. iv. of Extracts.*

³ The Ordnance Select Committee report, "although these shell roll considerably, owing to their great length and low velocity, yet their accuracy is satisfactory up to more than 2,000 yards, a range at which they would probably never be used. *Vide Ordnance Select Committee Report, 3858, 4/8/65.*

⁴ Note in priced vocabulary a 13-inch is enumerated, but there is no pattern or service shrapnel shell of this calibre.



Section at A A.
Scale $\frac{1}{4}$.



BOXER SHRAPNEL, 9'', II.

DETAILS of PATTERNS of BOXER SHRAPNEL.

Calibre and Numeral of Pattern.	Date of Approval.	§ of Changes in War Stores.	Length in Inches.	Nature of Balls contained.	Number of Balls.	Weighted Bursting Charge ("service pistol powder").	Weight of filled Shells in lbs.	Distance between Centres of Front and Rear Studs.	Bottom flat or rounded at Edge with a Radius of	Marks in Front of Front Stud.	On Rear Stud.	—
12" Mark I.	17/2/70	1873 ¹	30·75"	4-oz. sand shot -	530	18 oz.	lbs. oz. 496 2	7"	3·96"	I R↑L	Date and ×	
10" Mark I.	17/6/69	1806	31·88"	4-oz. sand shot -	488	1 lb.	383 0	8"	—	I R↑L	Date and ×	
9" Mark I.	21/3/68	1609	26·25"	2-oz. sand shot -	564	12 oz.	250 12	6"	3"	I R↑L	Date and ×	
8" Mark I.	21/3/68	1609	23·25"	2-oz. sand shot -	376	10 oz.	174 10	5"	2·65"	I R↑L	Date and ×	
7" Mark I.	{ Provslly 28/1/67 }	1390	17·95"	3-oz. mixed metal	200	8 oz.	111 8	—	Flat	I R↑L	Nil.	Cast-iron diaphragm on gutta-percha disc and flanges, buttons screwed in.
7" Mark II.	21/3/68	1609	19·72"	2-oz. sand shot -	227	8 oz.	112 8	4·6"	2"	II R↑L	Date and ×	Differs from I. in having wrought-iron diaphragm resting on shoulder formed by edge of powder chamber, also in having buttons staved in.

¹ § 1873 gives the bursting charge as F.G. powder by a mistake, it being shell F.G. powder, or, as it is now termed, "service pistol."

N.B.—The patterns of 9" and 8" Boxer shrapnel, approved provisionally by Changes of War Stores, § 1388, never having governed any supplies for service were withdrawn, and those approved in § 1609 substituted as Mark I.

These shells are painted black, except studs, socket, and screw plug. Paint.

Issue.

Issue.

1st. Filled for S.S. with primers inserted and with screw plugs in the fuze holes, marked filled in red, placed in jute bags for transit marked with the word filled and with the nature and calibre of the shell in red ; any issued since 11/4/70 also marked R \wedge L and W.

2nd. Empty for S.S. on L.S. with screw plugs, placed in jute bags for transit. Marked with the nature and calibre of the shell.

Use and Experience.

These shells form a very good cone of dispersion up to about 500 yards from the bursting point, of course for boats or compact columns it would be desirable to burst them much closer on the object than with more open formations.

PALLISER PROJECTILES.

It seems desirable before giving a description of the chilled projectiles now in the service, to enter on such an explanation of their character as will show the reasons for the qualities which they possess, but it does not seem necessary to give any lengthened account of their introduction, probably the following will suffice for most readers,—

¹In 1863, Major Palliser proposed a projectile of iron cast in a metal chill to render it hard for the penetration of armour, providing for the evil effects of brittleness by the form of head he gave to it which was an "elongated point."

These projectiles, as fired in 1864, were chilled to a considerable depth, but not throughout ;² they proved so successful that their manufacture was afterwards carried on in the Royal Laboratory, until Mr. Davidson, the manager of that department, so worked out the selection and trial of various samples of iron, and the method of conducting the manufacture in concert with Major Palliser, as to bring the projectiles to the state of efficiency in which they now exist in the service.

In those last manufactured the heads are cast in metal and the bodies in sand, the samples of iron being such that the heads are chilled white nearly to the centre, the bodies being an even mottle throughout.

In degree the powers of these projectiles excel those of the original Palliser shot, but the principle advocated by the inventor remains, viz., that a hard iron, chilled white, is used to punch, its deficiency in tenacity being met by the form of head employed, which belongs to one of the classes proposed by Major Palliser in the first instance.

To explain the nature of the iron employed, it is necessary to bring together a few well-known facts.

Molten iron (*i.e.* wrought iron) is hardly to be obtained under any circumstances, the Bessemer process being almost the only method of producing it. Dr. Percy in his work on iron and steel³ mentions his having at first doubted that it was actually obtained in that process. Effect of chilling on the metal.

¹ For a more full account, *vide* a paper written by Captain V. D. Majendie.—*Proceedings of Royal Artillery Institution*, vol. v., part 7, January 1867.

² I picked up fragments myself to investigate the truth of some remarks of Dr. Percy, and tested them in a rough way for the chemical condition of the carbon and the iron, which went to prove the above, viz., that the interior was in a very different state from the exterior.

³ Percy's *Metallurgy*, "Iron and Steel," p. 815.

Iron can, however, be readily melted in contact with carbon, but the result is no longer pure metallic iron, the metal having only fused as it became partly or entirely combined with carbon in some form of carbide, the exact proportions of which have never been satisfactorily determined (we may call it $\text{Fe}_x \text{C}_y$).

As this molten product cools under ordinary circumstances, the tendency of the carbon and iron is to separate more or less, should actual separation take place to any great extent the iron will become grey, showing crystals of metal and black masses of carbon, termed graphite ($\text{Fe} + \text{C}$); in some cases the separate particles are larger than others, thus gray hot blast has a coarser texture than grey cold blast iron.

Grey iron is in all cases soft and easily fused.

There is a curious indication of the kind of metal even in the molten mass, grey being known by a small breaking or cracking running rapidly in the film, which forms on the surface, the form being sometimes zigzag in cold blast grey, or small stars or spider shaped cracks, as in hot blast grey.¹

On the other hand should very little or no separation of carbon and iron occur, white iron will be the result, which is very hard and brittle, and difficult of fusion, giving a silvery fracture, and which is recognised in the molten state by the film breaking across in coarse broad cracks less continuously than the grey iron.

Without stating dogmatically what is the exact action of a blast furnace, which is liable to vary with circumstances, and is diffidently discussed even by metallurgists or manufacturers, it may be generally said, in spite of the fact that some samples of iron will be white and others grey, however they may be cooled, that any tendency of iron and carbon to separate is encouraged by slow cooling, and thus some irons which would be mottled if slowly cooled, may solidify into a kind of white iron if chilled or quickly cooled. This Major Palliser effected by the use of metal moulds, which chill in virtue of their conducting power.

To illustrate the action of metal as a conductor of heat, it is only necessary to remember that metal out of doors ordinarily feels colder to the touch than wood, cloth, or any less good conductor, the actual temperature is the same, but to the warm human body the metal feels colder, because it carries away warmth from the human body rapidly. In a Turkish bath, on the other hand, both metal and wood are hotter than the human body, and therefore the iron which conducts its excess of heat rapidly into the human body scorches it much more than the non-conducting wood or rug.

The effect therefore of a larger mass of metal such as a chill on molten iron, may at once be seen to be very great as compared with the comparatively non-conducting sand used in ordinary moulds, nor is this question greatly affected by the metal being warmed up to 80 or 100 degrees temperature, which is nothing compared to the heat of molten iron, in fact, metal is a rather better conductor when warm than when quite cold, and so chills rather more efficiently and immediately.

The iron thus rendered white possesses generally the qualities of white iron, that is, intense hardness and crushing strength and consider-

¹ Lieut. Ormsby, who was watching the operation of casting in the Royal Laboratory with me recently, called my attention to the appearance of a very minute pale flame in the centre of nearly every star, I do not know if this matter has ever been investigated specially; it seems likely that the carbon separating in contact with the air, forms carbonic oxide and carbonic acid, and hence the flame.

able brittleness, but it is probably rather denser,¹ and appears much finer and more silky in its fracture.

Now this being the opposite extreme to annealing, which renders metal uniform and even throughout its mass, it is not surprising that its particles should be in an unnatural and constrained condition, and that on slight provocation such molecular action should take place as would cause the projectile to split, and this has actually occurred under certain circumstances (*vide* pages 82, 91), and the chilling effect in manufacture is carefully carried out with a view to meet this in ways which need not here be noticed.

The Palliser projectiles then possess the following properties in an eminent degree:—

1. Intense hardness.
2. Crushing strength.
3. Brittleness or want of tenacity.
4. Increased density.

Hardness prevents the point from flattening in penetration, so that while the points even of steel shot are commonly found flattened after impact, those of chilled shot, however broken, retain their sharp form.

Crushing strength may appear at first to be very much the same as hardness, but while the latter relates to the rigidity of actual particles, the former applies to the rigid connection or building up of particles so as to resist their being forced in upon each other.

To compare glass and iron, the former has greater hardness, and the latter crushing strength, thus the former will scratch the latter but the latter will crush the former.

It seems probable that crushing strength is a very important element in Palliser projectiles, and it may be observed that in punching ordinary sheet iron with a steel punch, when sufficient force is applied, either the punch must crush or the part it presses must be torn out and separated from the rest of the sheet, thus the two opposing forces are the crushing strength of the punch and the tensile strength of the sheet iron.

It seems probable that this reasoning may hold good to some extent in the question of piercing armour plates, although it must not be applied without reserve to such a sudden performance of work as must here take place.

The form of head of Palliser projectiles is admirably suited to enable such metal to do its work in penetration when its surface is being pressed from front and sides towards one centre.

The fact that it actually resists crushing seems to be established by the circumstance that the fragments which are picked up are *remarkably cool* as compared with pieces of plate or of ordinary cast iron shot, for it is well known that material crushed or compressed becomes hot in the operation.

As to brittleness, it can hardly affect the front portion of the shot, pressed in as noticed above towards its centre; it is hard to say how much of its momentum the rear portion lends to the blow before it shivers away from it, but it is obvious that it is better here to have the iron in its rather less brittle, that is, its mottled condition.

Next, as to the form and distribution of metal in the projectile, the ogival of $1\frac{1}{2}$ radius, (*vide* p. 63) has been considered the best shape of head for shells.

¹ Some very limited experiments I made with the assistance of the chemical department as to this, gave an increase of density to mottled metal on casting in chills of about $3\frac{1}{2}$ per cent., and large as this is, I have reason to think it is likely to be correct.

Major Palliser has very naturally tried to get the metal forward as far as possible, so as to impress its momentum on the plate without acting through the medium of the sides or walls of the shell which must be made thicker as the base of the shell becomes heavier, and thus diminish the interior capacity and consequently the bursting charge.

Some premature explosions of these shells in the bores of guns have been attributed to the base being made so light as not to support the bush of the filling hole under the pressure of the firing charge of the guns, and hence a slight increase in metal was made in more recent patterns.

It will be seen that the shells at first made for certain calibres (9" and 8") had thicker walls and less capacity for powder than those since manufactured, the momentum of both shell being equal, the thinner shell being slightly increased in length to make it up in weight;¹ the relative advantages are increased explosive force in favour of the large capacity shells, and resistance to crushing in favour of those of small capacity, the former have been adopted, Palliser shot being associated with them.

As has been noticed above the projectiles (both shell and shot) recently manufactured in the Royal Laboratory have been cast in moulds of sand with metal ends for the heads, hence the head is regularly chilled and the body is evenly mottled iron; by this method the head has the full crushing strength while the body has more tenacity, and as has been said probably impresses rather more of its force on the target on impact, before it splits away from the head, but the main advantage in casting the bodies in sand is that the metal is believed to be far less subject to the action of the molecular forces which, as noticed above, may either split it in store or crack it so as to cause rupture in the bore of the gun. The studs, both of Palliser shell and shot have in all cases been attached by swedging into undercut holes in the projectiles.

PALLISER SHELL.

General Description.

Calibres 13", 12", 10", 9", 8", and 7". The form in every case is cylindro-conoidal, the head being ogival struck with a radius of $1\frac{1}{2}$ diameters.

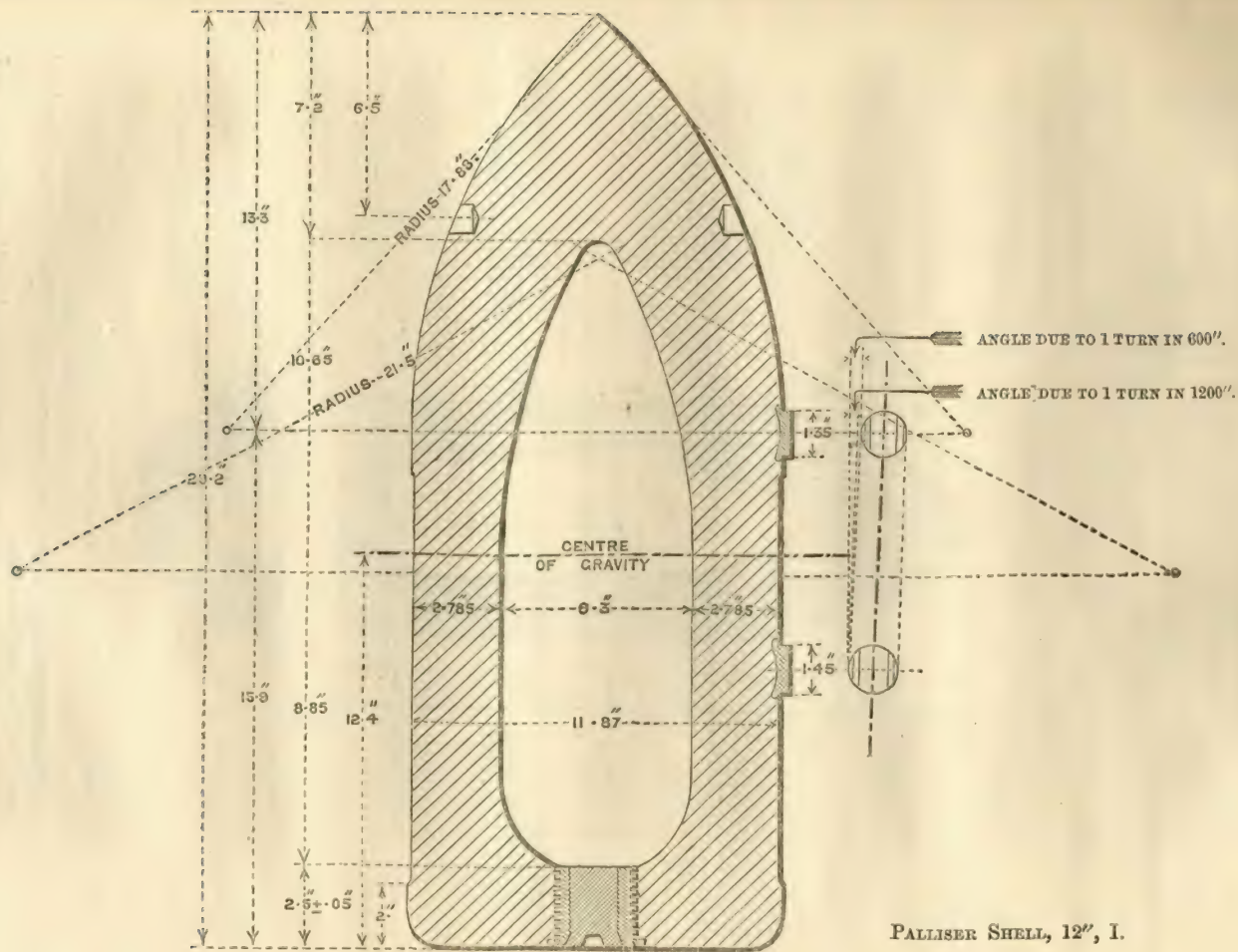
The total length varies between a little over 2 calibres and a little over $2\frac{1}{2}$ calibres, as may be seen on the table below.

The bottom is flat, in the more recent patterns it is rounded at the edge to facilitate loading.

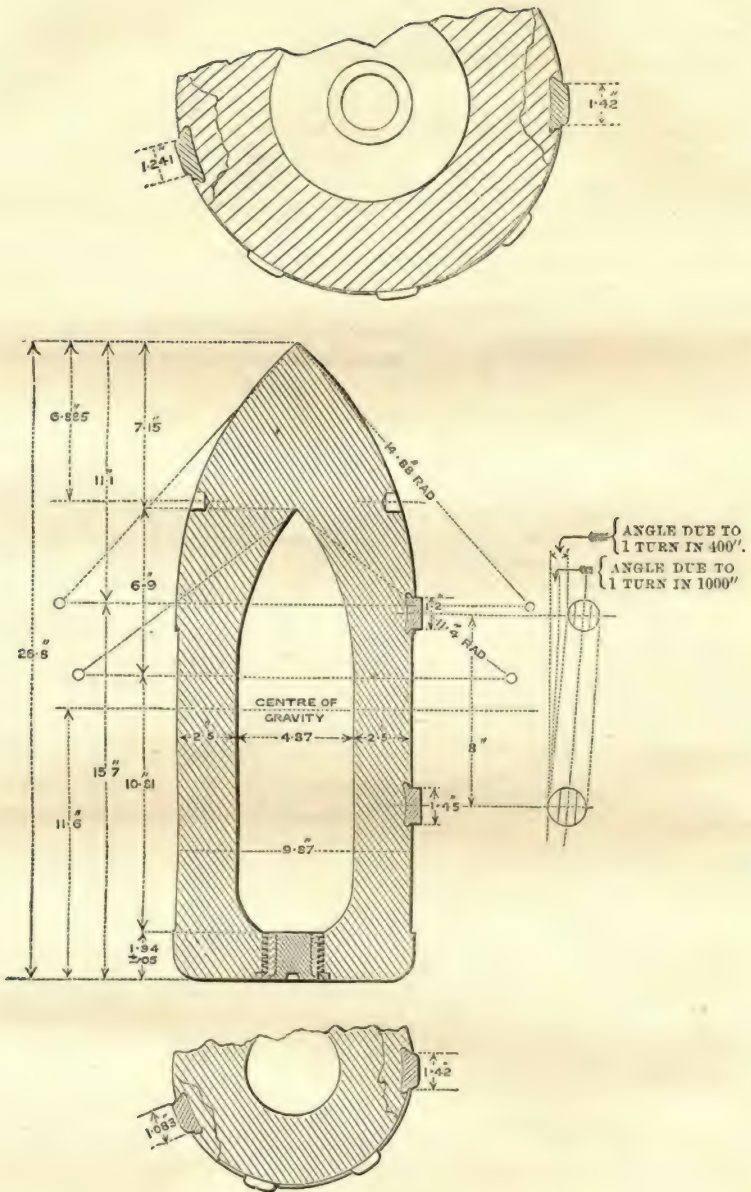
In the centre of the bottom is a filling hole bushed with wrought iron, and closed with a gun metal screw plug which should fit tightly and evenly, and is therefore selected for each shell, and is not intended to be interchanged with that of another.

The wrought-iron bush is cast into the shell, being placed for this purpose on the core spindle; it has grooves running round the exterior to cause the metal to enter and hold well in round it, and for more secure closing of the joint the top flange is removed in the form of an annular groove in the shell's base undercut towards the filling hole, and of such a width as to bring the junction of wrought and cast iron along the middle of the groove, into which is hammered a ring of lead, *vide* figure, p. 83.

¹ *Vide* Changes in War Stores, § 1518. It must not be assumed from the wording of this paragraph referred to, that all I. shells were of small capacity, for this is by no means the case.



PALLISER SHELL, 12", I.



PALLISER SHELL, 10", I.

The wrought iron is employed because it is impossible to tap the hard metal with a screw thread.

Owing to the great difficulty of cutting the chilled metal with a tool, the bodies were cast to their final dimensions in the metal chills. At first, to allow for limits of error, an increased windage, that is decreased diameter to the extent of .05" was allowed over the body, bands at shoulder and base, of the full diameter of other projectiles were cast on

them, these bands being narrow were easily brought down with a grindstone when necessary.

All Palliser shell manufactured previous to July 1870 are lacquered internally with the service red lacquer, but the lacquer being found occasionally to become detached in places, owing to the impossibility of always applying it when the shell has cooled to the precise temperature which best suits the operation of lacquering, it has been decided for the future to use a thin lacquer applied cold, and in all cases to employ serge bags shaped to fit the interior of the shell to prevent friction of the metal against the powder of the bursting charge.¹

As to marks, it should be observed that in the case of chilled bodies, except the date of manufacture, the X for hard metal, and E for examined (*vide* p. 87) which are made on the stud, all marks are cast on the base.

Sand cast bodies on the other hand have the numeral on the front stud.

One point has escaped without such definite marks as could be wished, and this must be specially noticed, *viz.*, the difference between 9" and 8" shells of large and small capacity. By reference to the Table below it will be seen that all the patterns except I. are of large capacity, containing bursting charges of 5 lbs. 14 ozs. and 4 lbs. 6 ozs. respectively, all shells then of II. and subsequent patterns are of large capacity.

The Table gives Mark I, shells of small capacity, *viz.*, the 9" to contain 2 lbs. 13 ozs. and the 8" 2 lbs. of powder, but unfortunately shells of large capacity were manufactured without changing the numeral, and therefore a Mark I. shell may be either a small capacity shell, as given in the Table, or it may be one of a large capacity, and the only method of identifying them, without testing their capacity, is a careful measurement of the length, those of large capacity being the same length as Mark II. shell given on the Table, but in numeral and other external marks resembling Pattern I.

Shell, rifled,
M.L. Palliser,
13, 12, 10, 9, 8,
and 7 inch.

Palliser shell were formerly painted black with a white ring and a red tip, but are now painted black with a white tip, the studs being in all cases left unpainted as with other projectiles.

Issue.

1st. Filled for S.S., the plug in the base having its wrench hole plugged up with red lead to enable a filled shell to be distinguished by the touch,² the shell is placed in a jute bag for transit, both shell and bag being marked "Filled" in red, and the bag being also marked with the nature and calibre of the shell in red, all issued since 14/4/70 from the Royal Laboratory would also have the date W and R \nearrow L in red.³

In future every Palliser shell will contain its bursting charge in a bag, and will be marked BAG (*vide* Appendix).

2nd. Empty for L.S. or S.S. with filling hole plugs, being placed in jute bags for transit, the bags being marked with the nature and calibre of the shell in black.

Use and Experience.

As has been noticed above, these shells are intended for use against armour-clad vessels, it is very uncertain if they would explode if fired against iron vessels not armour-plated, and they would probably altogether fail to burst against wooden ships.⁴ (For experience, *vide* p. 87.)

¹ *Vide* notes on experience, p. 87.

² *Vide* Changes in War Stores, § 1598.

³ " " " § 1880.

⁴ Lieut. Boxer, R.N., advocated the employment of a percussion fuze in the base of a Palliser shell to ensure the explosion in the event of a mistake as to the character of an adversary.

PALLISER SHELL.

Calibre and Numerical of Pattern.	Date of Approval.	§ of Changes in War Stores.	Length in Inches.	Weight, empty, in lbs. and ozs.	Approximate bursting Charge in lbs. and ozs.	Weight of filled shell in lbs., limits of.	Studs, Hard or Soft.	Distance between Centres of Front and Rear Studs.	Edge of Bottom rounded.	Bands round Shoulder and Base.	Bodies Cast in Sand.	Marks on Rear Stud, the Date referring to the Manufacture of each Individual Shell.	Marks on Bottom.
13" Mark I. -	{ Provsnlly 21/9/67 }	Nil.	27·3	lbs. oz. 600 0	lbs. oz. 18 0	618	Hard	" 9·69	No	No	No	Nil - -	PALLISER-B-RL-I-CHILL.
12" Mark I. -	11/11/68	1707	29·2	585 0	15 0	600	Hard	7	Yes	Yes	No	Date and × -	PALLISER-B-RL-I-CHILL.
12" Mark II.	7/3/70	1872	29·2	586 0	14 0	600	Hard	7	Yes	No	Yes	Date, ×, and II.	PALLISER-RL-P-II-CHILL.
10" Mark I. -	18/9/68	1678	26·8	391 0	9 0	400	Hard	8	Yes	Yes	No	Date and × -	PALLISER-B-RL-I-CHILL.
10" Mark II.	7/3/70	1872	26·3	393 2	6 14	400	Hard	8	Yes	No	Yes	Date, ×, and II.	PALLISER-RL-P-II-CHILL.
9" Mark I. -	{ Provsnlly 14/1/67 }	1386	20·2	247 3	2 13	250	Soft	8·7	No	No	No	Nil - -	PALLISER-B-RL-I-CHILL.
9" Mark II.	-	Nil.	21·5	244 2	5 14	250	Hard	6	No	Yes	No	Date and × -	PALLISER-B-RL-II-CHILL.
9" Mark III.	9/12/68	1765	21·45	244 2	5 14	250	Hard	6	Yes	Yes	No	Date and × -	PALLISER-B-RL-III-CHILL.
9" Mark IV.	7/3/70	1872	20·45	244 8	5 8	250	Hard	6	Yes	No	Yes	Date, ×, and IV.	PALLISER-RL-P-IV-CHILL.
8" Mark I. -	{ Provsnlly 14/1/67 }	1387	18·4	178 0	2 0	180	Soft	8	No	No	No	Nil - -	PALLISER-B-RL-I-CHILL.
8" Mark II.	11/67	Nil.	19·4	175 10	4 6	180	Hard	5	No	Yes	No	Date and × -	PALLISER-B-RL-II-CHILL.
8" Mark III.	9/12/68	1765	19·6	175 9½	4 6½	180	Hard	5	Yes	Yes	No	Date and × -	PALLISER-P-RL-III-CHILL.
8" Mark IV.	7/3/70	1872	19·25	175 8	4 8	180	Hard	5	Yes	No	Yes	Date, ×, and IV.	PALLISER-P-IV-CHILL.
7" Mark I. -	11/67	Nil.	16·4	112 8	2 8	115	Soft	4·6	No	Yes	No	Date and × -	PALLISER-I-RL-CHILL.
7" Mark II.	9/12/68	1765	16·5	112 8	2 8	115	Soft	4·6	Yes	Yes	No	Date and × -	PALLISER-CHILL-RL-P-II.
7" Mark III.	7/3/70	1872	16·5	112 8	2 8	115	Soft	4·6	Yes	No	Yes	Date, ×, and III.	PALLISER-CHILL-RL-P-III.

Changes in War Stores, § 1899, increase the high limit of error for diameter of Palliser projectiles by ·01 inch.

× indicates that the studs are formed to correspond to the curve of the groove (*vide* p. 57), and in all but 7-inch projectiles it also indicates that they are of the harder alloy.

B, D, and P are manufacturing marks referring to the quality of the iron.

Many 9" and 8" shells of large capacity were made as Mark I., these may be recognized from Mark I. small capacity by being respectively 1·3" and 1" longer.

The discovery of porous places under the surface of the bases of Palliser projectiles in the spring of 1870 led to a searching examination of those projectiles in store at Woolwich, and this defect was found to exist to a sufficient extent to render it expedient to extend the examination to certain out-stations, the cavities being detected by searching by slight blows with a pointed hammer; any flaws so discovered should be probed with a sharp wire, where the metal seems crumbling or globular in appearance, it will generally come away, and perhaps be followed by dust-like particles till a sound bottom is reached, a cavity of about the diameter and one-fourth the depth of an ordinary thimble may exist near the circumference of a shell or shot bottom without in the least weakening it, but it is ordered (in the instructions¹ for examination) that all shells which may appear "doubtful" are to be returned to Woolwich with those which appear "unserviceable."

All Palliser projectiles which have been formally examined and passed under this order have an E stamped on one front stud. The same mark is applied to all Palliser projectiles of subsequent manufacture.

The tip or point of a chilled projectile is occasionally broken off by the impact of a shell or shot rolled or struck obliquely against it; for, strange as it may appear, the point which may penetrate directly through many inches of armour without injury may be fractured by a very slight transverse blow. A shell with the entire point gone, even for the length of the eighth of an inch, would not be re-issued from Woolwich, and on service shells with perfect points should be preferred.

The service lacquer which holds very well to other projectiles is apt to chip away from the interior of Palliser shell; this arises from the fact that the projectile is not re-heated for lacquering, but undergoes this operation in the stage of cooling most nearly approaching to the proper temperature, hence an exact degree of heat is not to be attained, and consequently the lacquer does not always hold well to the metal; a thin black lacquer is approved for future manufacture which is applied cold.

At the same time, another possible cause of premature explosion in Palliser shell was discovered in the presence in these shells of particles cut from the wrought-iron bush in the operation of tapping, and either from the warmth generated in the operation, adhering to the lacquer or remaining in the curve of the interior of the shell so as to escape removal. In consequence of this it has been ordered that any powder removed from Palliser shell is to be treated as unserviceable,² and "at once thoroughly wetted and destroyed." Under these circumstances it has been decided to introduce serge bags to contain the bursting charge as an additional precaution against premature explosion; these bags are made bottle-shaped, and are introduced through the filling hole.³ All Palliser shells are completely filled with "shell powder L.G."

WOOLWICH PROJECTILES.

b. SHOT.

1. Palliser shot.
2. Case shot.

1. PALLISER SHOT.

Palliser shot.

Are all cored except 7, Mark I., which is solid.

The hollow up the centre renders the shot less liable to split in store from molecular action,⁴ it also slightly improves its proportions and shooting powers.

Calibres 12, 10, 9, 8 and 7 inch.

Calibres.

¹ See Circular on this subject, Appendix.

² Vide Changes in War Stores, § 1922, also Appendix.

³ Vide Appendix.

⁴ Vide Changes in War Stores, § 1518, also pp. 81, 82, and 91.

These projectiles externally closely resemble Palliser shell.¹ The 12 and 10 inch are made with ogival heads of $1\frac{1}{2}$ diameters radius, and the 9, 8, and 7 inch cored shot with ogival heads of $1\frac{1}{4}$ diameters radius.

All have a hollow running up the axis of the body and entering the base of the head, this hollow being formed in casting like that of a shell by a core, hence the name of cored shot.

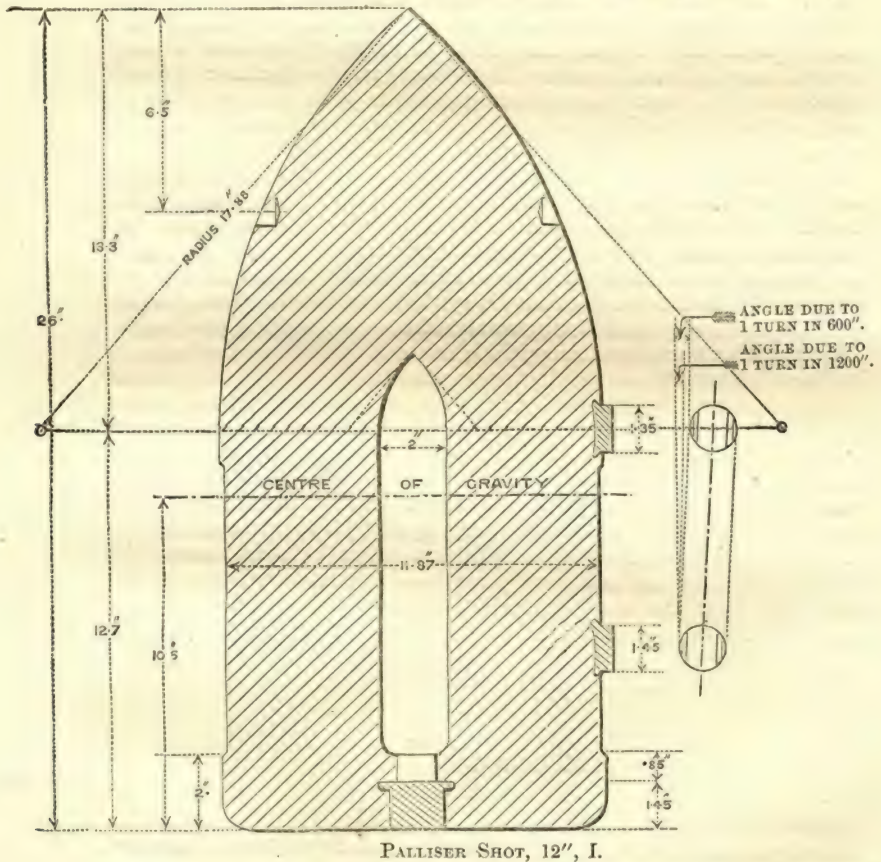
The 7-inch solid shot has an ogival head struck with a radius of one diameter.

The base was formerly closed by a wrought-iron plug hammered in;² it is now bushed with a wrought-iron bush cast in and sealed with lead like that of Palliser shell;³ it has a wrought-iron screw plug which is made with a square head, nicked to enable it to be twisted off and filed flush after screwing home.

These projectiles being of the same weight as the Palliser shell have the same momentum, and are superior only in solidity of head and sides; they offer a slight advantage in economy.⁴

The details of patterns may be seen on the following Table (p. 90).

Shot, rifled,
M.L. Palliser,
12, 10, 9, 8,
and 7 inch.

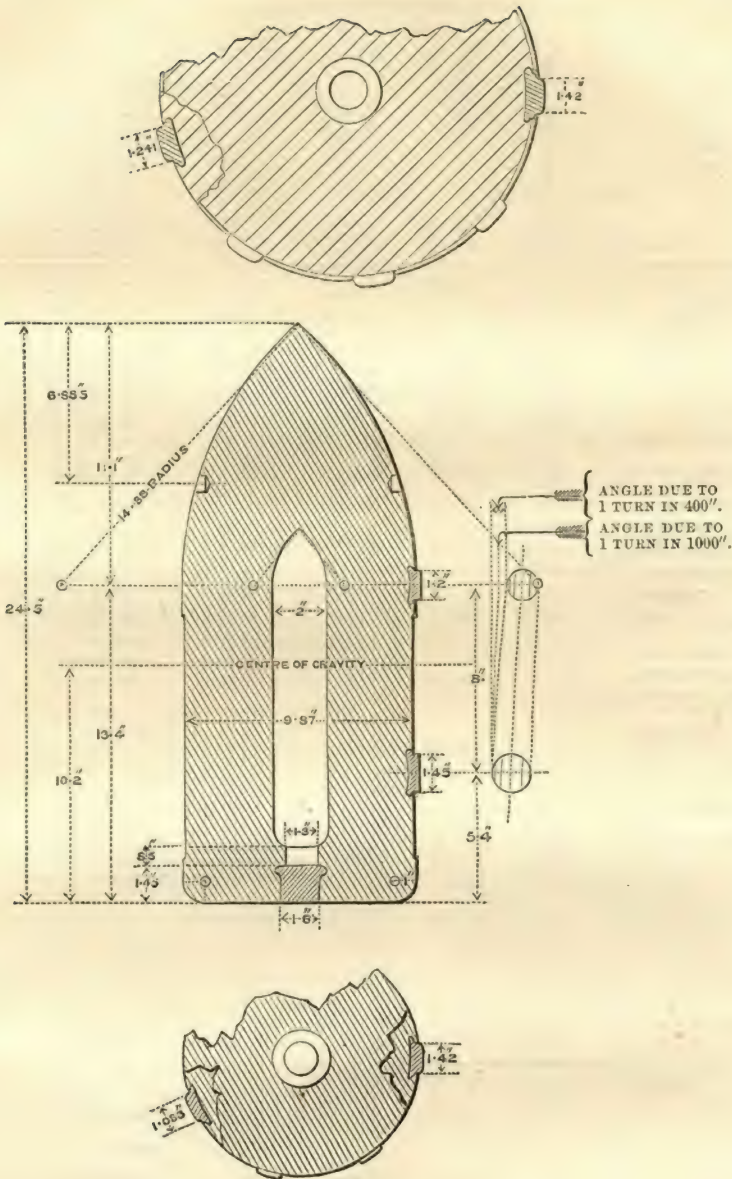


¹ For consideration of qualities of metal, &c., *vide* p. 79.

² Shot so made have since had a strengthening plug screwed in when returned to Royal Laboratory, *vide* p. 91.

³ *Vide* pp. 82, 83. It is carried out in the following patterns, 12" and 10", Mark II., 9" and 8", Mark III., and 7", Mark V.

⁴ The priced vocabulary enumerates a 13-inch Palliser shot, but no such projectile has been manufactured *for service*.



PALLISER SHOT, 10", I.

A Palliser shot was formerly distinguished by being painted black Paint. with a white ring round the head, but such projectiles are now painted black all over except the studs.

If necessary jute bags are used on Palliser shot for transit.^{1, 2}

Issue.

¹ For experience *vide* pp. 87 and 91.

² *Vide* Changes in War Stores, §§ 1517 and 1588.

PALLISER SHOT.

Calibre and Numeral of Pattern.	Date of Approval.	\$ of Changes in War Stores.	Length in Inches.	Weight in lbs.	Studs, Hard or Soft.	Radius of Arc with which the Head is described in Terms of the Diameter of Projectile.	Distance between the Centres of Front and Rear Studs.	Edge of Bottom rounded.	Bands round Shoulder and Base.	Bodies Cast in Sand.	Marks on Rear Studs, the Date referring to the Manufacture of each Individual Shot.	Marks on Bottom.
12" Mark I. - 12" Mark II. ¹	11/11/68 7/3/70	1707 1872	26 26·2	600 600	Hard Hard	1½ 1½	Inches. 7 7	Yes Yes	Yes No	No Yes	Date and × - Date, ×, and II.	PALLISER-B-RL-I-CHILL. PALLISER-P-RL-II-CHILL.
10" Mark I. - 10" Mark II. ¹	{ Provs only 18/9/68 } 7/3/70	1678 1872	24·5 24·5	{ actual } 410½ 400	Hard Hard	1½ 1½	8 8	Yes Yes	Yes No	No Yes	Date and × - Date, ×, and II.	PALLISER-B-RL-I-CHILL. PALLISER-II-RL-I-P-CHILL.
9" Mark I. - 9" Mark II. 9" Mark III. ¹	21/10/67 9/12/68 7/3/70	1518 1765 1872	18·8 19 19·1	250 250 250	Hard Hard Hard	1½ 1½ 1¼	6 6 6	No Yes Yes	Yes Yes No	No No Yes	Date and × - Date and × - Date, ×, and III.	PALLISER-B-RL-I-CHILL. PALLISER-B-RL-II-CHILL. PALLISER-P-RL-III-CHILL.
8" Mark I. - 8" Mark II. 8" Mark III. ¹	21/10/67 9/12/68 7/3/70	1518 1765 1872	17·15 17·35 17·4	180 180 180	Hard Hard Hard	1½ 1½ 1½	5 5 5	No Yes Yes	Yes Yes No	No No Yes	Date and × - Date and × - Date, ×, and III.	PALLISER-B-RL-I-CHILL. PALLISER-B-RL-II-CHILL. PALLISER-P-RL-III-CHILL.
7" Mark I. ² - 7" Mark II. 7" Mark III. 7" Mark IV. 7" Mark V. ¹	- { Provs only 18/12/66 } 21/10/67 9/12/68 7/3/70	- 1340 1518 1765 1872	- 14 14·55 14·7 14·7	- 115 115 115 115	- Soft Soft Soft Soft	- 1 1½ 1½ 1½	- 6·1 4·6 4·6 4·6	- No No No Yes	- No Yes Yes No	- No No No Yes	- Nil - - Date and × - Date and × - Date, ×, and V.	- CHILL-II-B-RL (solid). PALLISER-R-I-III-CHILL. PALLISER-CHILL-RL-IV-B. PALLISER-CHILL-RL-P-V.

¹ These patterns have the wrought-iron bush common to Palliser shell, closed by a wrought-iron screw plug whose head is twisted off and cut flush, *vide* preceding page.

² A few experimental issues, no pattern extant.

PALLISER SHOT.

It has been noticed that Palliser shot when cast solid had a tendency Experience. to fracture spontaneously, or on slight provocation in store, and to a less extent the same evil has existed in cored shot; it has been attributed partly to the system at first pursued of closing the base with a wrought-iron plug swedged into an undercut hole; it appears that this has a tendency to split the shot, and indeed it has since been found on the same principle that a cracked projectile may be surprising easily divided in two by a blow on the stud fixed on the present system. If shot are found split in store, the crack generally runs through stud holes.

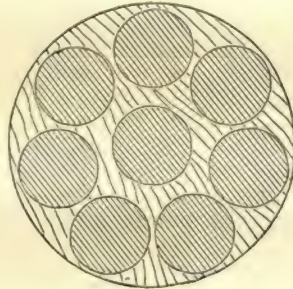
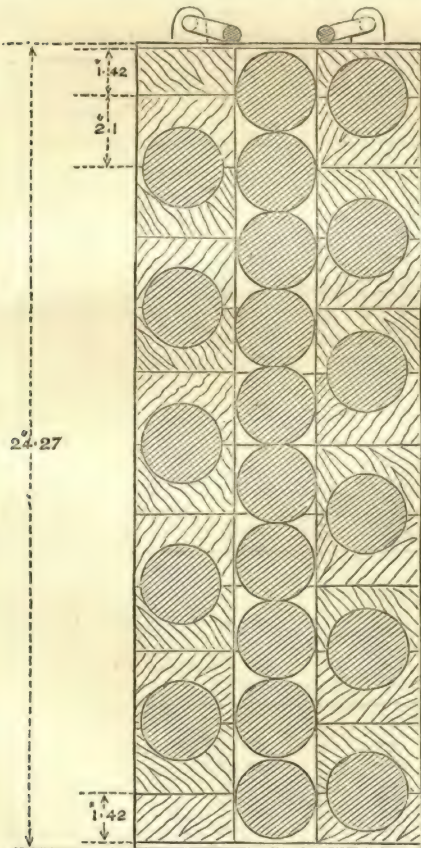
To remedy this evil, the wrought-iron bush and screw plug of Palliser shot of the last pattern have been adopted, and to repair and strengthen the shot of previous patterns, the wrought-iron plug has been bored out, and tapped to take a screw plug of wrought-iron with a strong rounded head, extending past the supposed seat of weakness.

Shot are returned to Woolwich to undergo this operation.

CASE SHOT.

Case shot.

The general principles of construction of case have been discussed under the head of breech-loading projectiles (*vide* pp. 43, 48, and 49). Reeves' pattern was provisionally approved for the 9" calibre as well as for the 7-inch B.L. and M.L., as noticed above. All the patterns since



REEVES CASE, 9", I.

CASE SHOT.

Calibre and Numeral of Pattern.	Date of Approval.	\$ of Changes in War Stores.	Length in Inches.	No. of Handles.	Nature of Balls contained.	No. of Balls.	Total Weight of Balls contained.	Weight of Lining or Segments.	Weight of Coal Dust.	Total Weight.	Marks on Case Top.
12" Mark I. -	6/5/69	1777	11.35	2	8-oz. sand shot -	255	lbs. oz. —	lbs. oz. —	lbs. oz. —	lbs. oz. 230 0	I, R \nearrow L, 12 IN., M. L.
10" Mark I. -	{ Provsly 27/1/68 }	—	9.6	—	8-oz. sand shot -	136	—	55 10	6 6	130 0	I, R \nearrow L, 10 IN., M. L.
9" Mark I. -	{ Provsly 24/3/68 }	1241	24.2	2	2-lb. sand shot -	96	—	—	—	189 8	W \nearrow D, 9 IN., M. L. (Reeves' pattern wood discs.)
9" Mark II.	24/3/68	1611	9.1	2 {	6-oz. sand shot - Mixed metal musket Mixed metal pistol -	168 50 58	}	—	—	96 4	II., 9 IN., W \nearrow D, M. L. (A few only issued.)
9" Mark III.	24/3/68	1611	9.1	—	8-oz. sand shot -	113					
8" Mark I. -	24/3/68	1611	8.4	—	8-oz. sand shot -	75	36 15 $\frac{1}{4}$	25 11 $\frac{1}{4}$	5 5 $\frac{1}{2}$	68 0	I, W \nearrow D, 8 IN., M. L.
7" Mark I. -	29/6/66	1241	22	1	1-lb. sand shot -	87	—	—	—	102 0	I, W \nearrow D, 7 IN., M. L. or B. L. (Reeves' pattern.)
7" Mark II.	24/3/68	1611	10.4	1 {	6-oz. sand shot - Mixed metal musket Mixed metal pistol -	112 23 22	}	—	—	67 0	II., W \nearrow D, 7 IN., M. L. or B. L. (A few only issued.)
7" Mark III.	24/3/68	1611	10.25	—	8-oz. sand shot -	74					

manufactured have been the so-called Royal Laboratory pattern, with segmental linings and coal dust, sand shot of 8 oz. weight being used, and the weight being governed by the law laid down by the Committee, viz., that is for the 7-inch calibre three-fourths the weight of projectile, and for larger natures the weight of a round shot of the same calibre (*vide* p. 44). The diameter is slightly less than that of other projectiles of the same calibre, in all except 12" the high limit of the former is the mean of the latter.¹

The general character of the case shot is that it carries close, and is intended for longer ranges than smooth-bore case, but this is effected at a great sacrifice of weight of missile, not only from the entire projectile being so light, but also from the segmental linings being very heavy, as may be seen in the preceding Table, which gives the details of each pattern. Paint, black, formerly red. Issue, loose.

Shot, rifled,
M.L. case,
12, 10, 9, 8,
and 7 inch.

N.B.—Wooden dummies resembling Palliser shot, painted black, are used for drill; they have staples in the points for attaching a line to.

Wooden
dummies.

SPECIAL EQUIPMENTS FOR 7-PR. M.L. AND FOR 9-PR., ADOPTED FOR INDIA.

The French system (so called) adopted with the 7-pr. mountain gun² of 3 inches calibre, has three grooves .6 inches broad at bottom, and .1 inch deep. A cross section gives the edges straight lines inclined to each other at 90°, the driving edge being at 70°, the loading edge at 56°, with the radii from the centre of the bore through their respective points of junction with the surface of the bore.

The twist is rapid and uniform, viz., 1 in 20 calibres. The arguments in favour of an increasing twist apply chiefly to large calibres (*vide* pages 55 and 56).

The system introduced for the field gun for India closely resembles this as far as concerns the projectiles; the calibre is the same, the twist is uniform, 1 in 30 calibres (*i.e.*, 1 in 90 inches); the depth of groove is .11 inch.

It was found by the Committee (appointed to investigate this matter³ in the end of 1868) that better results were obtained with this system, which was advocated by Col. Maxwell, then with the Woolwich, the projectiles having a rather greater initial velocity, and giving better shooting.

It is believed also that on this system the projectile is actually centred, whereas, as has been shown above, the Woolwich groove cannot effect this to an appreciable degree.

The studs of the projectiles are of zinc, both those for the 7-pr. and for the Indian gun being swedged into undercut holes; two studs are employed for each groove, and great stress must be laid on this point in the case of the Indian gun, for the bore being bronze and the projectile iron, the soft zinc studs are the medium by which both direction and rotation⁴ are given, whereas in the case of the Woolwich the bore is steel, and firing with one ring of studs only has been contemplated and tried experimentally, *vide* p. 58.

The impression taken of the bore of a 9-pr. bronze gun after it has fired a large number of rounds, exhibits the effects of the action of

¹ The priced vocabulary enumerates a 13" case, but there is no such projectile in the service.

² *Vide* Changes in War Stores, § 1506.

³ Committee on Field Artillery Equipment for India, Major-General Wilmot, President, R.A., first meeting, 17th December 1868.

⁴ This Committee remark that the stud projects .13 inches, and the depth of groove being .11 inches, in the case of the shell lying in the bore with a groove beneath it, the weight would be borne by the stud in the groove, there being a clearance of .02 between shell body and bore, beneath the shell and .04 inch over it before it begins to move, but when centering takes place there would be about .03 inches all round the body.

grooves and studs in a most remarkable way; deep furrows are shown running longitudinally up the bore, caused by erosion of the gas in all parts except the driving edges of the grooves which remain smooth and polished. This is no doubt due to the part they perform; it seems probable that the constant rubbing of the studs smooths down all irregularities, and burnishes the driving edges of the grooves, and so prevents erosion taking place continuously on any spot. It is stated until these bearings are so far worn down as to allow the body of the shell to touch the bore the shooting continues good.¹

The projectiles for the 7-pr. and 9-pr. closely resemble each other, the chief difference throughout being in the size and position of studs, and the general proportions of the projectiles.

The guns are the same calibre, and their projectiles the same diameter, hence that for the 9-pr. is in each case longer than that for the 7-pr.; the studs in the former are much smaller and further apart.

N.B.—Up to the present time the fuze hole of 7-pr. shells has been made of the common gauge, and its plugs have therefore a cross-cut on them, interchanging with plugs of smooth-bore common shell, but the recent adoption of the general service gauge for the 9-pr. has naturally led to the proposal to manufacture all future 7-pr. shells with the same fuze hole, in order to assimilate the gauges of all M.L. rifled shell garrison and field. Obviously an effort should be made to prevent the employment in the same field force of two sets of *non-interchangeable fuzes* resembling each other as closely as the 5, 10, and 15 second fuzes for the 7-pr., and the 5 seconds and 9 seconds M.L.O. fuzes, besides the 20 seconds M.L.O.

The equipments of these small M.L. guns then at the present time are complicated, but the complication extends only to a very limited supply, which it is hoped will rapidly die out. After the experience the British Artillery have had in elaborate material connected with rifled ammunition it seems worth an effort to secure a promise of simplicity even, though the fulfilment be deferred until the disappearance of B.L. ordnance. The scheme contemplated is to bring every kind of M.L. rifled shell fuze hole to the general service gauge. As this has also come in for naval smooth-bore shells, it will be seen this scheme is indeed worth carrying out.

The projectiles of the 7-pr. are as follows:—

- | | |
|------------------|--------------------|
| 1. Common shell. | 3. Shrapnel shell. |
| 2. Double shell. | 4. Case shot. |

Common shell.

COMMON SHELL, CALIBRES 9-PR. AND 7-PR.

Calibres.

The former is nearly three calibres long, and the latter rather over two calibres in length; both heads are ogival 7·5" radius; both shells are lacquered internally with red lacquer; both are filled completely with "shell powder L.G."; their fuze holes are unbushed, the diameter of each shell is 2·94".

The 9-pr. has the general service gauge fuze hole, the 7-pr. mark I. that of the common gauge.

The details of patterns are as follows:—

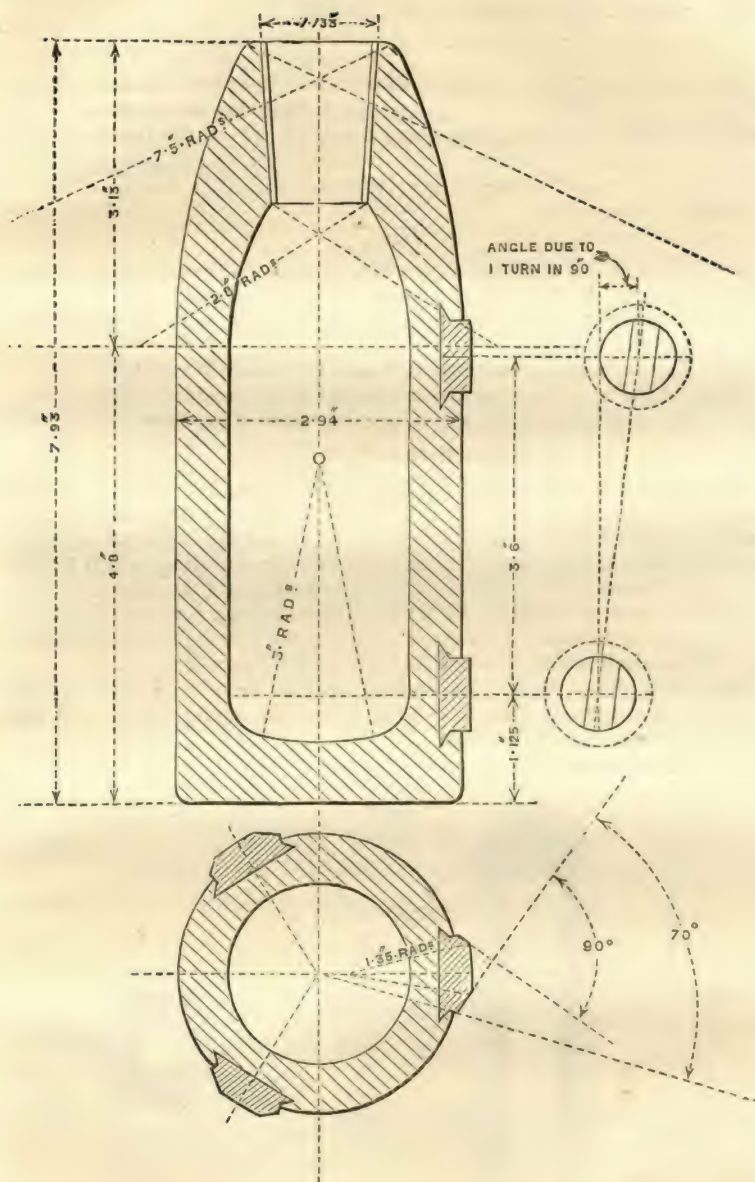
9-pr.

Approved 4/1/70. Changes, § 1921. Length, 7·93"; weight, 8 lbs. 8 oz.; capacity for bursting charge, 8 oz. Marks, on side, $\begin{smallmatrix} I \\ R \end{smallmatrix} \nearrow L$, on base, RL, date on rear stud.

Details of patterns.

9-pr. (not entered in vocabulary).

¹ The Committee on Field Artillery Equipment for India report a gun as much in this state after firing 2,000 rounds, and even after 2,732 rounds the iron body of the projectile was believed in no instance to have come in contact with the bore.



9-PR. M.L. COMMON SHELL, MARK I.

Shell, rifled,
M.L. common,
7-pr.

7-pr.

Approved 4/12/65. Changes, § 1153. Length, 6.75"; standard weight, 6 lbs. 14 oz.; capacity for bursting charge, 7 oz. Marks on side near base, R \uparrow L, on base, RL.

The fuze hole of this shell, as noticed above, is of the common gauge; owing to the difficulty experienced in forcing in the millboard was carried in filled shells, the edges and lower threads of the fuze hole are slightly removed with a rimer; this is tested by a special gauge.

It takes the 5 and 10 second special Boxer M.L.R.O. fuzes.

Black, except studs.

Paint.
Issue.

Issue.

1st. Filled, with shell L.G. powder, waxed millboard was in fuze hole, in boxes. Shell and box marked "Filled" in red.

All issued since 11/4/70 to be marked R \uparrow L, W, with date of filling, also in red, *vide* § 1880.

2nd. Empty, with screw plug, in boxes for transit if required.

These shells have been packed in special boxes containing eight rounds each in the case of the 7-pr. shells, and ten each of the 9-prs.

Double shell,
7-pr.

DOUBLE SHELL (7-PR. ONLY).

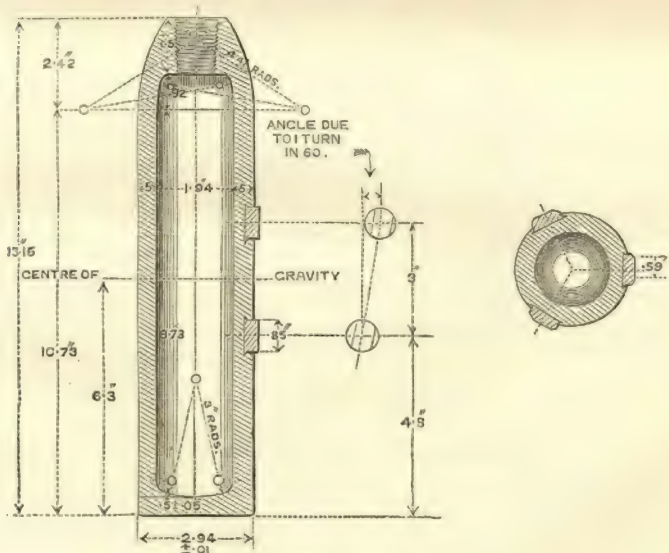
This shell was introduced for firing at high angles, with a reduced charge (4 oz.), and enables the gun to be used as a small howitzer or mortar; in fact supplies a modified form of vertical fire, differing from the regular system in the charge being fixed and the elevation varied to suit the range, instead of the elevation being constant and the charge varied.

The first pattern of shell was found rather too long for good shooting, but the idea is valuable, and gives an extended power to the mountain gun. The shell is filled completely with "shell powder L.G."

The shell differs from the common only in certain dimensions, the diameter, fuze hole, lacquer, and plug being the same. Fuzes, 10 and 15 second Boxer special M.L.R.O.

Details of pat-
terns.

The details of patterns are as follows:—



DOUBLE SHELL, I.

1st. Approved provisionally 9/10/67.¹ Length, 13·15"; standard weight, 13 lbs. 2 oz.; capacity for bursting charge, 1 lb. Marks in front of front stud $R \begin{smallmatrix} \uparrow \\ I \end{smallmatrix} L$, on base $R L$, date on stud. Shell, rifled, M.L. double, 7-pr.

2nd. Approved² 30/12/68. Length, 11·25"; standard weight, 11 lbs.; capacity for bursting charge, 1 lb. Marks in front of front stud, $R \begin{smallmatrix} \uparrow \\ II \end{smallmatrix} L$, on base $R L$, on rear stud date.

Black except studs.

Paint.
Issue.

Issue.

1st. Filled, with waxed wad underneath plug, in boxes, marked "Filled" in red. Any since 11/4/70 to be marked $R \begin{smallmatrix} \uparrow \\ L \end{smallmatrix} W$ and date of filling, also in red, *vide* § 1880.

2nd. Empty, in boxes if required for transit.

These shells have been packed in special boxes, eight in each box.

SHRAPNEL SHELL (9-PR. AND 7-PR.).

Shrapnel shell.

The former is nearly three calibres, the latter rather over two calibres long (diameter of each 2·94").

The shells are constructed on the same principle as those for larger natures of guns; the proportions are necessarily different, the fuze hole being larger and the wood head smaller in comparison to the body.

The diaphragm is cast iron in Mark I, 7-pr., and placed on three flanges, and wrought iron supported on the shoulders of the chamber, which has a tin lining (as in Mark II., shells for Woolwich guns) in subsequent patterns of 7-pr. and all 9-pr. shells. There are six lines of least resistance in all cases.

The central tube takes the same gun-metal primer as is used for larger natures. The 9-pr. has a G.S. gauge bush, and takes the 5-second M.L.O. fuze.

The 7-pr. has at present a bush of common gauge, and takes the 5-second special Boxer M.L.R.O. fuze.

The details of patterns are as follows:—

Details of patterns.

9-pr.

Approved³ 4/1/70. Length, 7·93"; weight, 9 lbs. 4 oz.; contains 28 bullets 18 to the lb., and 35 bullets 34 to the lb.; bursting charge, 12 drams, "service" "Pistol." Marks on side near base $R \begin{smallmatrix} \uparrow \\ I \end{smallmatrix} L$, on base $R L$. 9-pr. (not entered in vocabulary).

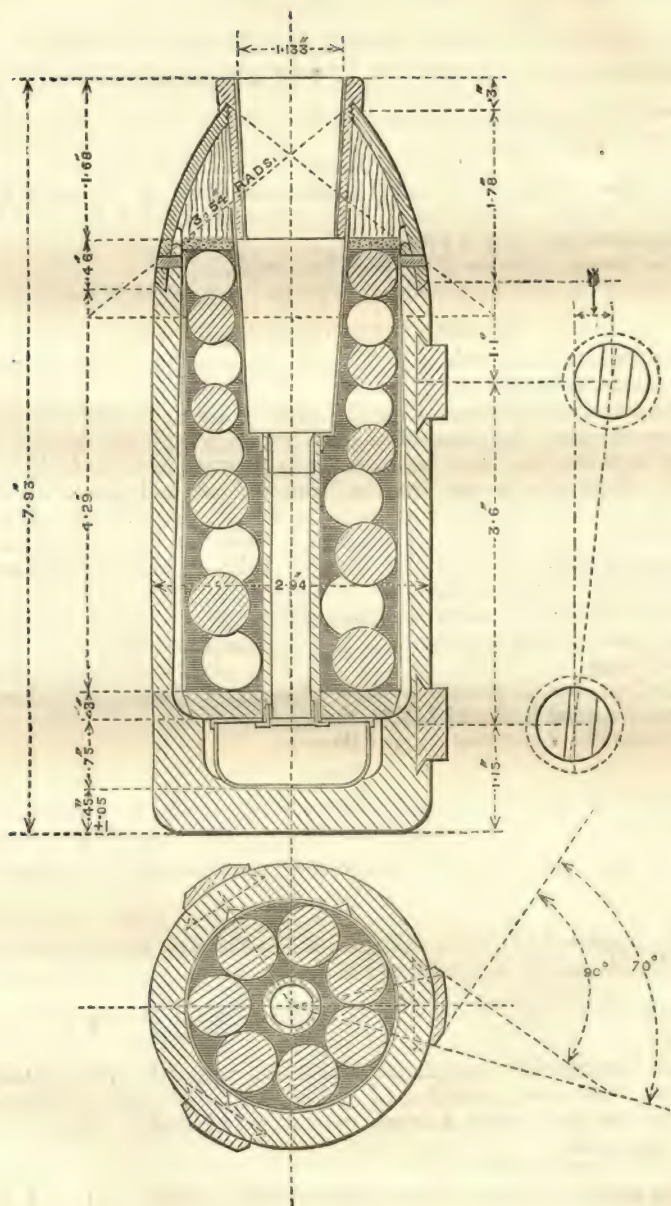
7-pr.

1st. Approved⁴ 18/2/67. Length, 6·5"; standard weight, 7 lbs. 6 oz.; contains 21 bullets, 18 per lb., and 21 bullets 34 per lb.; bursting charge, 8 drams, "service" "Pistol." Marks on side near base $R \begin{smallmatrix} \uparrow \\ I \end{smallmatrix} L$, on base $R L$. Shell, rifled, M.L. Shrapnel-Boxer, 7-pr.

2nd. Approved⁵ provisionally 19/3/68. Length, 6·5"; standard weight, 7 lbs. 5 oz.; contains 21 bullets 18 per lb., and 21 bullets 34 per lb.; bursting charge, 8 drams, "service" "Pistol." Marks on side near base $R \begin{smallmatrix} \uparrow \\ II \end{smallmatrix} L$, on base $R L$.

The bodies of these shells are painted black, except studs, and heads red, except bush.

¹ *Vide* Changes in War Stores, § 1520.
² " " " " § 1779.
³ " " " " § 1921.
⁴ " " " " § 1392.
⁵ " " " " § 1600.



9-PR. M.L. BOXER SHRAPNEL.

Issue.

1st. Filled, and with primers inserted, marked in the same way as other filled shells, but in black letters on the red heads.

2nd. Empty, with screw plugs.

Both 9-pr. and 7-pr. have been packed in special boxes, to contain 10 rounds in each case.

CASE SHOT. CALIBRES, 9-PR. AND 7-PR.

*Issue.**Calibres.*

The first case shot for the 7-pr. gun consisted of a simple tin case containing mixed metal balls, but subsequent patterns were made on the so-called Laboratory method of construction, the envelope being tin, the two bottoms and lining being of sheet iron, No. 12 W.G. and 15 W.G. respectively. The diameter is in every case 2·94".

DETAILS OF PATTERNS, 9-PR.

Approved¹ 4/7/70. Length, 7·4 inches \pm ·1 inch; standard weight, 9 lbs. 12 oz. \pm 4 oz. Consists of a tin case with zinc disc laid inside, and zinc bottom riveted outside (No. 10 Birmingham wire gauge, or ·134 inch thick). It has lining of three zinc segments (·083 inch thick or 14 Birmingham wire gauge). Weight of case and lining, 2 lbs. 2 oz., resin and sand in equal parts 14 oz. Contents 110² mixed metal balls (16½ to the lb.). Weight 6 lbs. 12 oz. Marks, 9-pr. R \nearrow L I.

Shot, rifled,
M.L. case, 9-pr.

The interstices are filled up with equal parts of resin and sand, over the balls and resin is laid a piece of wood to bring the projectile up to the same length as the shell and so facilitate packing in limber boxes.

This case shot has an iron knob handle attached by turning the end of the case over. It will be noticed that this case devised by the Committee of Field Equipment for India, does not conform to the regulation laid down by the Ordnance Select Committee, quoted on p. 44, but is heavier and more powerful; the zinc lining is less liable to injure the bore than an iron one, and the resin fixes the balls better for travelling.

Black.

DETAILS OF PATTERNS, 7-PR.

1st. Approved³ provisionally 4/12/65. Length, 5·6"; standard weight, 7 lbs. 8 oz. Consists of a tin case, weight 1 lb. 8 oz. containing 48 loose bullets of mixed metal weighing 6 lbs. Marks on top I.

Paint.

Details of patterns.

2nd. Approved⁴ 9/9/67. Length, 5·2"; standard weight, 5 lbs. 4 oz. Contents, 36 sand shot (1½ oz.). The case is of tin plate with a lining of three iron segments; it has a double bottom of sheet iron besides the tin. Marks W \nearrow D, 7-pr., M L, II.

Shot, rifled,
M.L. case, 7-pr.

3rd. Approved⁵ 31/7/69. Length, 4·7"; weight of case and lining, 1 lb. 5 oz. Contents, 82 mixed metal balls (1 oz.), 5 lbs. 4 oz. Coal dust, 5 oz. Total weight, 6 lbs. 14 oz. Marks on top, R \nearrow L, 7-pr., M L.

Issue.

Case shot have been issued in special boxes, 10 rounds in each box, both with 7 and 9 prs.

EXPERIENCE.

Some difficulty was experienced in Abyssinia in forcing in the mill-board wad with the fuze, hence it has been decided to remove the edges of the lower screw threads of the fuze hole to facilitate this operation; a gauge is issued to test it; the metal removed is too little to be readily detected by the eye.

Experience with 7-pr. common shells.

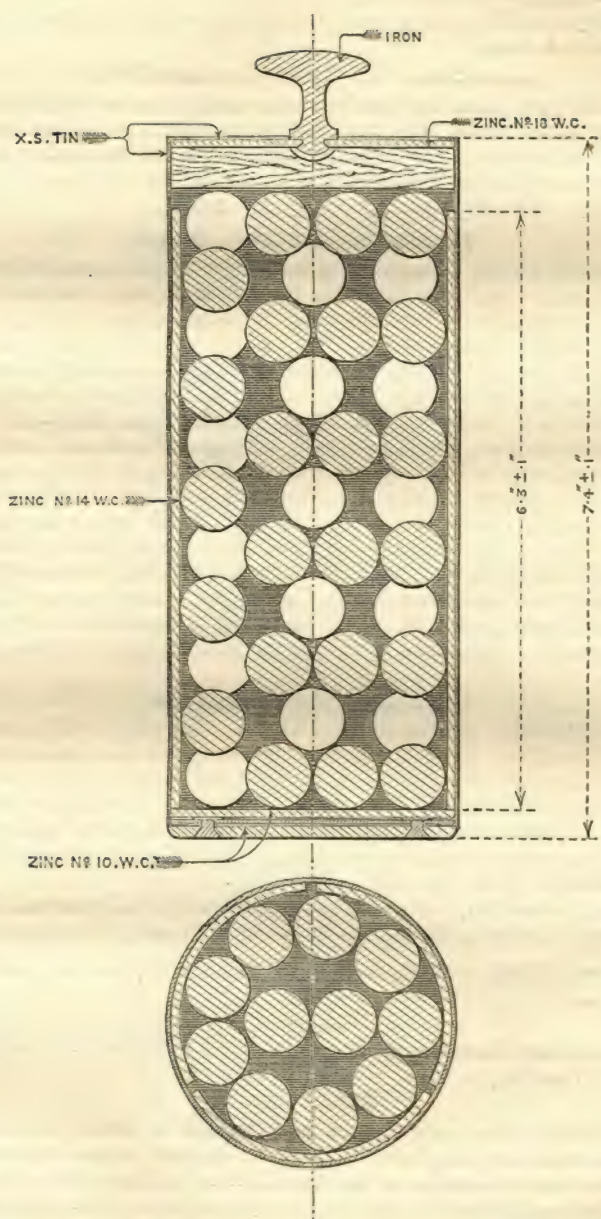
¹ Vide Changes in War Stores, § 1921.

² Three parts lead to one of antimony.

³ Vide Changes in War Stores, § 1153.

⁴ " " " § 1468.

⁵ " " " § 1814.



Experience with Shrapnel (Active Service).

This has been confined to the Campaign in Abyssinia, and to the 7-pr. shell which did well.¹

Experience
with shrapnel.
Active service.

FUZE HOLE PLUGS.

The following descriptions of gun-metal fuze hole plugs have been issued for rifled shells, besides some white metal plugs which have long been condemned, being superseded by those of gun-metal by Changes of War Stores, § 281, May 17th, 1861 :—

Plugs, metal
fuze hole.

1. Plug, metal, fuze hole, with string loop, large.
2. " " " general service.
3. " " " with string loop, small.
4. " " " common.

The large plug with string loop is the same plug as was formerly used for S. B. naval shell, and being of the Moorsom gauge it is now obsolete, the G.S. adapter being permanently fixed in the shells with the Moorsom gauge bush; that is the larger natures of B.L. common and segment shells, and the 64-pr. M.L. common shell.

This is a conical screw plug, with neither ², ³ head, leather collar, nor string loop, in the top is a square wrench hole; it is used in all shells with the general service fuze hole, viz. :—⁴, ⁵, ⁶.

Plugs, metal
fuze hole, G.S.

All common, double, and shrapnel shells for Woolwich guns.

All shrapnel for 7" 64 and 40 pr. B.L., and 64-pr. M.L. guns.

All common shells for 7" 64, 40, and 20 pr. B.L., and 64-pr. M.L., either with G.S. gauge fuze hole or G.S. adapter.

All segment shells for 7" 64 and 40 pr. B.L. guns with G.S. adapter, besides S.B. naval shells with adapters.

The present pattern B.L. field service plug was approved in March 1868; it superseded a similar one of weaker construction ⁷ approved in November 1861.

Plug, metal
fuze hole, with
string loop,
small.

The loop is intended for lifting the shell out of the limber box.

These plugs have heads and special leather collars (*vide* p. 99).



¹ *Vide* Extracts from Proceedings, &c., relative to segment and shrapnel.

Extracts from Col. Milward's remarks on equipment of mountain batteries.

"Common and shrapnel shell good in all respects, but should be fitted for percussion fuzes."

Extracts from Lieut. Chapman's Journal of Practice.

8/1/68.—"2 rounds shrapnel at about 470 yards, 5 seconds fuze. Practice good."

10/1/68.—"Shrapnel at 700 yards was ineffective."

11/1/68.—"2 rounds shrapnel at 450 yards, very effective."

Action of 10/4/68.—"The shrapnel and common shell took great effect at ranges from 500 to 1,500 yards," "the effect of the shrapnel was considered good. 55 rounds were fired."

² *Vide* Changes in War Stores, §§ 1838 and

³ *Vide* Note on Ammunition, Part I., by Captain V. D. Majendie, p. 99.

⁴ *Vide* Changes in War Stores, §§ 1238, 1301.

⁵ " " " 1062.

⁶ " " " 424.

⁷ In August 1861 the string had been ordered to be cut off from the plugs of patterns previous to those above mentioned, and lifting tongs used to remove the shells from the limbers, but the latter were abolished in October 1865. *Vide* Changes in War Stores, § 1159.

Plug, metal
fuze hole,
common, II.

This plug was approved in March 1868,¹ to supersede the common plug I.; it is made on the principle of the general service plug without either head or leather collar, a conical plug being found to close more thoroughly by having no head which might check it before the conical bearings were fast home; there is also a saving in expense.

This plug is marked with a cross cut like the one it supersedes; it is used in the 7-pr. shells with the common gauge fuze hole as well as in smooth-bore common shell.

N.B.—Plugs for unloading holes have not been sealed as a separate store, being issued in the shells.²

LEATHER COLLARS.

Collars,
leather, fuze
and plug, large
and small,
rified.

In addition to the large and small collar of smooth-bores, which have been used in rifled material (viz., large for Moorsom gauge fuzes and plugs, and the small for O.P. plugs for 7-pr. shell), there is one special collar for fuzes and plugs of field service B.L. gauge (E and F time, C screw and plug).

There is no separate scaled pattern, but the F fuze is sealed with a leather collar on it.

Gutta-percha collars have been tried, but they become brittle and chip off very soon, especially in hot climates.

MISCELLANEOUS STORES.

Papier-mâché Wads.

Wads, papier-
mâché, socket
of B.L. com-
mon shells.

This is simply a small wad of paper rolled and pressed, with a cavity in the centre both above and below (*vide* fig. below). It is inserted in all filled common shell B.L. 20, 12, and 9 pr. Mark II., that is, all field service common shell having flanged sockets. Marks R \uparrow L.

Changes in War Stores, § 1708, directs this wad to be used as follows :—



“The shell having been filled (care being taken that no powder remains in the socket), the wad is placed, with the recessed part uppermost, in the hole at the bottom of the socket, and driven in flush. Any flat-ended piece of wood or stick larger in diameter than the wad may be used for this purpose.”

The object of the wad being used is to prevent the powder from working into the socket.

It is not necessary to remove the wad when the shell is to be fired, as the explosion of the fuze is sufficient to force it into the shell.

Millboard Wad for Fuze-hole Recess.

Wad, papier-
mâché, fuze
hole of rifled
shells.

Changes in War Stores, § 1346, describes this store nearly as follows :—

“A millboard wad, saturated with beeswax, for insertion in the fuze-hole recess of every empty rifled shell that has either the general service or the Moorsom fuze-hole, when issued for naval service, in order to protect the plug and prevent corrosion, has been sealed. Pattern I.”

The wad is also to be substituted for the “kit plaster” now in use for covering the fuze-holes of empty shell for *rified* guns when issued in lieu of hollow-bodied shot (§1190).

¹ *Vide* Changes in War Stores, § 1603.
² “ ” “ § 1764.

The wad is to be driven into the recess of the fuze-hole above the plug. One surface is painted blue. It is marked I.

Diameter of wad, 1·63 inch; thickness, 0·2 inch.

The "kit plaster" is at once to be removed from the shells, and the millboard wad substituted in its place.

Approved 30th November 1866, 75/12/3008.

Resembles that for common gauge fuze hole given in Notes on Smooth-bore, Part I., page 106, except that is made concavo-concave in form so as to be more easily driven in by the end of the fuze, and that it is of ·985" to ·99" diameter, to suit the G.S. gauge (thickness ·25", Marks I. A wad 1·02" to 1·025" diameter, perforated so as not to impede the flash of a percussion fuze, but covered with shalloon on the lower side, has been used, and may supersede the above.

Wad, papier-mâché, fuze hole general service.

Bolton Wads.

For 12", 10", 9", 8", and 7" muzzle-loading rifled guns. Superseded the papier-mâché gun wads given below.

Wads, Bolton, gun, rifled (Mark I.)

Changes in War Stores, § 1801, describes this wad as follows:—

"These wads are made of pulp prepared from 75 per cent. of old rags known as 'tammies' or 'woollens,' and 25 per cent. of old tarred rope, formed in a mould, and coated with a waterproof varnish when dry."

Instrument for Extracting Projectiles for 64-pr. Muzzle-Loading Gun.



This wad is used next the base of the projectile the cupped side being towards the charge) to prevent excessive erosion of the bore near the seat of shell from the rush of gas.

These wads have all been supplied by contract.

For 9", 8", and 7" muzzle-loading guns¹:—

These wads were designed to act in the same way as the Bolton wads, by which they were superseded almost immediately. A few however were issued, and are available for service.

Wads, papier-mâché, gun.

Extractors.

The 64-pr. projectile extracting instrument, Mark II.² is as follows:—

Instrument extracting projectile, rifled M.L. gun, 64-pr.

It consists of an ash staff fixed in an iron socket, into which screws the head of the extractor.

The head has three projecting horns or guides, which are made to fit and enter the three grooves of the gun. Through the bases of these are hinged or pivoted three iron levers, each forming a long jaw with a tooth at the end and a short counter lever or counter jaw.

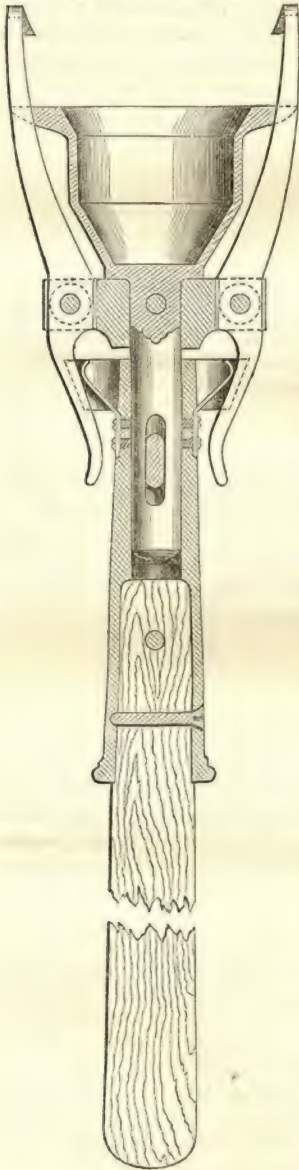
The staff socket has a collar fitted so as to let it turn in it, in which are fixed three pins, one running through an inclined slot cut in each counter-jaw. By this arrangement the staff may be twisted or screwed round by hand, so as to make it and its collar recede or advance so that its collar pins moving in the slots open or close the counterjaws, closing or opening the jaws, and seizing or releasing the projectile at the three extractor holes.

¹ Vide Changes in War Stores, § 1863, which gives dimensions. The date of approval was July 1868.

² Vide Changes in War Stores, §§ 1205 and 1712.

It will be seen the action of this extractor depends on the guides bringing the teeth of the jaws over the extractor holes which are opposite the grooves. This form of extractor cannot be used with guns with an increasing twist unless a ring be cut round the head of the projectile

Instrument, Extracting Projectiles,
for Woolwich Guns.



Instrument
extracting
projectile,
rifled M.L.
gun.

Instrument
extracting,
7", 8", and 9",
II.

to enable the teeth to change their position with the increasing twist of the groove.

The ash handle now has a screw thread cut in the wood to give a better grip. No change of numeral.

The extractor Mark I. is omitted. It differed in details, the counterjaws being opened with an advancing cone and closed with an india-rubber ring. It is hardly to be met with in the service.¹

This extractor is marked on the stove socket with calibre, numeral, and R \uparrow L or W \uparrow D.

Projectile Extracting Instrument for Woolwich Guns.

An instrument for the 9" and 7" projectiles, resembling the one above described for the 64-pr., was first adopted² (24/1/66 and 8/5/66); that for the 9" was only provisionally scaled. Common 9" shell were made with a groove round the head to enable this extractor to work with the grooves on increasing twist.

The extractor since made for every calibre of Woolwich projectile is constructed on a different principle, so as to act independently of the grooves of the gun.

It has two jaws and teeth for the two extractor holes of the projectile.

The jaws are closed by a strong spring acting on each counterjaw. The increasing twist, as above noticed, prevents the use of guides. The extractor is pushed home until the edge of a cup in its head (*vide figure*) bears on the edge of the projectile. It is then turned round until the teeth spring into the holes, which are placed at a fixed distance from the ring on the head on which the cup edge will rest.

On withdrawing the staff the socket moves slightly in a slot in the shaft of the head, bringing two wedges, fixed on each side of each spring, to support each counterjaw.

This extractor has no means provided for releasing its hold while in the bore.

¹ *Vide Changes in War Stores*, § 1020.

² " " §§ 1206 and 1266.

Mark II. for the 9" and 7", and Mark I. for the 8",¹ have smooth staves; but Mark III. for 9" and 7", Mark II. for the 8",² and Mark I. adapted for 13", 12" and 10"³ have a groove like a screw thread running up the stave to give a better hold to the hand.

Each instrument is marked at junction of cup and shaft of the head with the calibre the instrument is for, the numeral, and R \nearrow L; some have W \nearrow D.

Mark II., 9" and 7".
Mark I. and II. 8".
Mark III., 9" and 7".
Mark I., 13", 12", 10".
Marking.

*Bags for Extracting Instruments.*⁴

There are two sizes of bags made of painted canvas, the mouth constructed to draw round the stave, and tied with small cord running through eyelet holes.

The larger size is for the 13", 12", and 10" extractor; the smaller for the 9", the 8", the 7", or the 64-pr. extractor.

Each bag is marked I. and R \nearrow L in white paint.

Bags for extracting instruments.

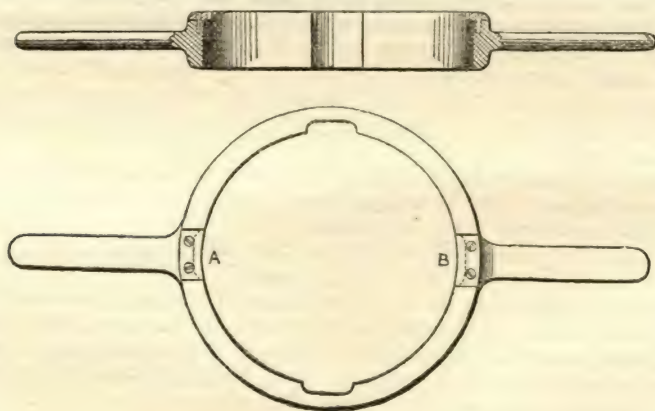
Holder, Shell, Palliser.

12-inch, approved⁵ October 1868.

10-inch, " " ⁶ September 1868.

9, 8, and 7 inch, approved⁷ August 1867.

This, although an "implement," can hardly be omitted here; it consists in each case of a wrought-iron ring of an internal diameter .03 inches less than the nominal calibre in each case, or generally above .05 inches in excess of the diameter of the projectile. Thus the 7-inch shell, whose diameter is 6.92" in some patterns, though from limits allowed averaging slightly over that in the last pattern, has a holder 6.97" in diameter; each holder is grooved to correspond to the rear ring of studs on the shell on which it rests, the shell being placed point down on a block or in the soft ground, and the holders slipped over the base; it has small plates which prevent its passing lower down the shell than the rear ring of studs (*vide fig. below*).



¹	Vide Changes in War Stores,	\$ 1363.
²	" "	\$ 1712.
³	" "	\$ 1681, 18/9/68.
⁴	" "	\$ 1734.
⁵	" "	\$ 1696.
⁶	" "	\$ 1682.
⁷	" "	\$ 1483.

	7	8	9
<i>AB Diameter</i>	6.97	7.97	8.97
<i>N^o of Grooves.</i>	3	4	6

It has two handles by which the holder and shell are held and steadied while unscrewing the filling hole plug or filling the shell.

A boxwood drift for inserting wads in G.S. fuze holes has been approved, Feb. 1870.

Pliers for Shrapnel Primers.

Pliers for removing primers from shrapnel shell after unscrewing the same are now obsolete.

Gauges.

Are of two kinds.

1st. Ring gauges for B.L. and M.L. projectiles.

2nd. Cylinder gauges for M.L. projectiles.

There are five ring gauges for each B.L. projectile still used in manufacture, and formerly issued to stations of inspection, viz. :—

1 for commencement of taper near point.

1 high and 1 low for body.

1 " and 1 " for back end.

Pliers for
shrapnel
primers.

Gauges, two
kinds.

Gauges, iron,
shell or shot,
rifled, breech-
loading, ring.

Gauging a B.L.
projectile.

In gauging a B.L. projectile standing on a table, the high back end should descend over the entire projectile and lie on the table; the low back end gauge should stop at the commencement of the back end behind the cannellure (in 7" and 64-pr. Boxer shrapnel the front cannellure of the two); the high body gauge should descend and rest on the last-mentioned one.

The proper position for the low body and commencement of taper gauges to rest is not so well defined, but the former should not pass over what is obviously the full diameter of the body, and the latter should stop at a point a little above it.

It was ordered in September 1866¹ that two gauges only should be issued to stations of inspection, viz., that given above as low for back end, and either the high gauge enlarged to the same diameter as the "test ring" given below, or else the actual "test ring" now in the service; in fact, this "test ring" becomes the "high gauge" for future issue, the converted high gauge only differing from it in not having a wooden handle.

Low ring gauges have been made for the studs of every nature of M.L. projectile; ² they have been issued to stations of inspection, but are of little practical value for service.

2nd. Gauges, iron, cylinder, shell or shot rifled muzzle-loading.

Calibres, 12",³ 10",⁴ 9", 8", and 7"⁵ and 64-pr.

Cylinder gauges for M.L. projectiles with the uniform twist have grooves in them corresponding to the grooves in the gun; both cylinder and groove are .045" less diameter than in the actual gun. Such a gauge is therefore a high gauge for both body and studs of projectile, which it should pass over freely, and thus ensure its entering the bore of the gun.

For projectiles with the increasing twist the gauge has a groove to every row of studs, narrowed at top so as to test the driving and

¹ *Vide Changes in War Stores*, § 1314.

² " " " " §§ 1313 and 1547.

³ " " " " § 1714.

⁴ " " " " § 1697.

⁵ " " " " § 1546.

Gauges, iron,
shell or shot,
rifled, muzzle-
loading, ring.

Gauges, iron,
cylinder, shell
or shot, rifled,
muzzle-load-
ing.

loading edges of both front and rear studs at the same time; there is a flange round the top of the gauge which should rest fair on the front stud, a small slot being cut in it to enable this adjustment to be visible.

This gauge is again a high gauge, to ensure the projectile from jamming.

The 9" and 8" cylinder gauges have both the sets of grooves described above, and hence in one position they pass over the entire projectile, and in the other rest on the front ring of studs.

The only ring gauges sealed are those for the 64-pr. B.L. projectiles, and for 64-pr. and 12", 10", 9", 8", and 7" M.L. Those for M.L. projectiles have wooden handles as well as those formerly sealed as test rings.

Test Rings.¹

For 7", 64, 40, 20, 12, or 9 pr., and 6-pr. B.L. projectiles, are iron Test rings. rings with wooden handles, like low ring gauges for M.L. projectiles. They are to be called "high gauges," and issued as such for the future.

They are slightly larger than the old pattern high back end gauge (in the case of the 64-pr. '102" and in that of the 12 or 9 pr. '026").

Both test rings, and high gauges brought up to the diameter of the so-called test ring, will become the "high gauge" of the future, and will be used to test projectiles which have travelled in limbers, &c., being the only gauges issued to field batteries, who should from time to time ascertain that any projectiles that appear to have suffered or have travelled much will pass through them, and if not a sufficient portion of the lead to enable this to be done may be removed by filing. Use.

It should be clearly understood that the test ring requires no alteration whatever to make it into the high gauge approved for future use, 7/9/66, Changes in War Stores, § 1314, except the change of name. Marking.

¹ Vide Changes in War Stores, § 1017.

² " " " § 1314.

(N.B.—The foregoing pages corrected up to September 30th, 1870.)

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